DOCUMENT RESUME

ED 353 218 SP 034 185

AUTHOR	Volkov, Vladimir M.; Milner, Evgeny G.
TITLE	Man and Running. Russia's Best-Selling Book on Exercise, Health, and Medicine. A Worldwide Literature Search.
INSTITUTION	American Alliance for Health, Physical Education, Recreation and Dance, Reston, VA. National Association for Sport and Physical Education.
REPORT NO	ISBN-0-88314-527-8
PUB DATE	92
NOTE	136p.; Translated from Russian by Daniel C. Drew and others. Original Soviet publisher: Izdatelstvo Physkultura I Sport, Moscow, 1987.
AVAILABLE FROM	AAHPERD, 1900 Association Drive, Reston, VA 22091.
PUB TYPE	Information Analyses (070)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Adults; Aerobics; *Cardiovascular System; *Exercise Physiology; Foreign Countries; Health Promotion; Heart Disorders; Literature Reviews; *Physical Fitness; *Running; *Sports Medicine; *Training
IDENTIFIERS	*Russia

ABSTRACT

This book attempts to systematize and generalize the data of world literature concerning the advantages of fast walking and slow running for persons with various cardiovascular diseases. The information and the fitness program outlined are based on experience and research conducted at the Nadezha Health Club in Smolensk, Russia. Major risk factors for cardiovascular disease are discussed, as well as how development of coronary disease can be attenuated or arrested by a prolonged routine of jogging. The effects of fitness running are also outlined in relation to certain diseases and conditions: diseases of the blood vessels of the lower extremities, neurasthenia, gastro-intestinal disease, diabetes, and obesity. A section is also included on running and injuries. The risk factors discussed include: high serum cholesterol, diastolic hypertension, obesity, smoking, unfavorable heredity, insufficient motor activity, and excessive nutrition high in calories. The fundamentals of training which should be applied to fitness running focus on three principles: repetition, incremental improvement, and individualization. Instruction in the basics of fitness running as well as the stages of training vary according to the health, conditioning, and age of participants. Correct planning of weekly and monthly workouts is essential to achieve health benefits. Postexercise recovery should be worked into the routine: a pattern of alternating workouts with rest days. (IAH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED353218

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

G Anderson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it

☐ Minor changes have been made to improve reproduction quality

● Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

MAN & RUNNING

BEST COPY AVAILABLE

2

SP034185

Man
and
Running

Russia's Best-Selling Book on Exercise, Health, and Medicine

A Worldwide Literature Search
by Russian Sports-Medicine Expert
VLADIMIR M. VOLKOV, Ph.D.
and Noted Russian Sports Physician
EVGENY G. MILNER, M.D., Ph.D.

Translation Supervised and Finalized by
DANIEL C. DREW, M.D., A.B.F.P.

with assistance from
Michael Levin, Aldo Rondelli, and Bodan Cymbala, M.D.

NATIONAL ASSOCIATION FOR SPORT AND PHYSICAL EDUCATION
an association of the
AMERICAN ALLIANCE FOR HEALTH, PHYSICAL EDUCATION,
RECREATION AND DANCE

Original Soviet publisher:
Izdatelstvo Physkultura I Sport, Moscow, 1987

Cover photo credit: Michael Kacmarcik

Copyright © 1992
American Alliance for Health,
Physical Education, Recreation and Dance
1900 Association Drive, Reston, VA 22091

ISBN 0-88314-527-8

Table of Contents

- Authors' Preface v
- Translator's Prologue vi
- Foreword ix
- Chapter One—Physical Activity and Health 1
  - Running and Disease in the Twentieth Century 1
    - Faulty Cholesterol Metabolism 2
    - High Blood Pressure 5
    - Obesity 7
    - Smoking 8
    - Ominous Heredity 9
    - Inactivity and Over-Eating 11
  - Running Against Cancer 15
  - Running and Longevity 17
  - Running and Working Capacity 21
- Chapter Two—The Basics of Exercise Physiology 25
- Chapter Three—Fundamentals of Training 43
  - Principles of Training 43
    - The Principle of Repetition 43
    - The Principle of Incremental Improvement 44
    - The Principle of Individualization 44
  - Ways and Means for Training 45
  - Training Load and Intensity 48
  - Stages of Training 57
  - Planning Your Training 59
  - Problems Encountered in Marathon Running 65
  - Fitness Running and Competition 68
  - Running and Self-Management Functional Tests 71
  - Direct Measurement of Maximum Oxygen Utilization 73
  - Indirect Measurement of VO_2 Using Nomogram of Astrand-Riming 76
  - Determination of Work Tolerance 77

PWC_{170} Test 77

Determination of Physical Fitness Using the Test of Cooper 78

A "Lesson After the Bell" 79

Chapter Four—Running and Medicine 81

Running and Cardiovascular Disease 82

Can Running Help in the Battle Against Coronary Insufficiency? 86

Effectiveness of Rehabilitation 95

Running and Diseases of the Vessels of the Lower Extremities 101

Running and Neurasthenia 102

Running and Gastro-Intestinal Disease 103

Running and Diabetes 104

Running and "Those Extra Pounds" 105

Running and Injuries 107

Literature Citations 115

Authors' Preface

We have tried to examine objectively and without embellishment the entire diversity of problems and issues regarding fitness running, with its ups and downs, its joys and sufferings, its flourishing present and its even more promising future.

An attempt has been made to systematize and generalize the data of the world literature concerning the advantages of using fast walking and slow running for persons with various cardiovascular diseases. Also, conclusions are suggested based on the analysis of fifteen years of experience and results of scientific research carried out at the "Nadezhda" (Hope) Health Club in Smolensk. Over this period, more than 500 middle aged and elderly men and women were introduced to fitness running.

We will demonstrate how to prevent diseases and prolong youth. We believe we can help the reader to appreciate the joy of running and convert it into a reliable ally in the struggle against aging. Throughout the book we have also tried to set forth the scientific information clearly and accessibly, yet we are aware that we may have not been totally successful, and for this, readers deserve our apology. We expect that the book will generate some discussion inasmuch as the medical and biological aspects of fitness running are a domain which has not yet been deeply or seriously scrutinized. We will therefore welcome and appreciate any and all criticism.

Vladimir M. Volkov, Ph.D.
Evgeny G. Milner, M.D.

Translator's Prologue

The dramatic events which unfolded in the Soviet Union during 1991, as this book was being translated and readied for press, have resulted in a complete transformation in the relationship between Russia and the western world. Though the shroud of mystery and secrecy has been lifted, and the "iron curtain" disassembled, we have enjoyed only a few short months of the new "openness." Surely we westerners will be dealing for a long time with our curiosity and questions about "who are the Russians, and what makes them tick?"

In the interest of time and simplicity, I have chosen to spare my readers a lengthy background dissertation on the Soviet Union, Russia, and the recent "revolution." I submit that an alternative is afforded by a very prevalent aphorism which I consider to be valid, pertinent and direct: "*Never be surprised at what happens in Russia!*" I must tell you, readers, that this book is indeed the result of a whole sequence of surprises, and I suspect that reading it will bring on a few surprises for each of you.

Although I had been teaching my patients all the teachings of Dr. Ken Cooper, as all good family doctors should, I reached age 42 fat, frustrated, and overworked. I took my patients' advice and began a daily running program in 1982—and "voila"—the doctor was right. You know what I mean, or you wouldn't be reading this.

Until 1985 all I knew about our "enemies" in the Soviet Union was the traditional stereotypic information of the day: "different, evil, and dangerous"—with an occasional hint that it might be changing or that it might even be incorrect. But in 1985, at the urging of a friend, and to satisfy a yen to do something both outrageous and humanitarian I joined the World Runners' tour to the annual Moscow Peace Marathon.

To make a long story short, everything I had ever learned about the Soviet Union exploded in my face. The stereotypic teaching did not jive with my experience. "Different" melted into "just like us!" "Evil" gave way to "loving!" "Dangerous" evolved to "peace-loving." I returned home feeling like Marco Polo, speaking of a land that no one knew about.

The list of names and addresses I brought home (doctors, fathers, fitness runners, and other "counterparts") blossomed into budding pen-pals and later into fast friendships. I have returned seven times, often with my family, for the Peace Marathon, for citizen diplomacy events, for "running club tours," and for a medical seminar on fitness and mental health. My log tallies nearly 80 days, seven republics, and a long litany of friends and colleagues.

The Russian way of thinking and living is indeed different from ours and difficult for a westerner to understand. The Russian soul is not! It is just like ours. Human life is the most valuable thing on the planet—true for us and for

8

them! All activities and systems should be designed for the protection and improvement of human life and the quality of life—true for us and for them—even to the writing of a book about running.

Why such a book would impress me will be evident in the reading. How the translation came about is a "story" I'll tell in a minute, but some facts must precede the story.

A cursory review of the book's literature citations reveals that about 25% of the quoted "world literature" on this subject is in the Russian language literature, while 75% of the citations are from Western Europe, Canada, America, Japan, Australia, and New Zealand. (It appears that the Chinese literature was not reviewed.)

Although this "mix" is not the least bit surprising, it does bring out a fact that is still surprising to most Americans today: The collective linguistic skills of the Soviet scientific community vastly surpass not only our own linguistic capabilities, but our very understanding of the Soviets.

In spite of their perceived "backwardness," the Soviets have proven their excellence, and even superiority in many areas—of which language skills are just one example. Music, art, poetry, environmental protection, and education are other examples. If the learning disabled are excluded, a recent WHO study has shown that illiteracy in the Soviet Union is near zero. There are more teachers of English in the Soviet Union than there are students of Russian in the United States.

And thus, while the Soviet scholars, students, and researchers avidly translate and abstract the deluge of Western literature, a mere trickle of Soviet learning and teaching reaches our data bases. Until recently, the prevailing myth that "we are enemies" has worked in synergy with this lopsided exchange of information to create the delusion that the Soviets held all their research and new information to be "secret."

A single visit with any Soviet physician or scientist usually dispels the myth as well as the delusion—except for those who are hopelessly wedded to myths and delusions. My own experience during many visits and many ongoing friendships with Soviet physicians, scientists, and running enthusiasts is that they not only like and admire "us," but they are also eager for us to share their newest ideas as well as their ongoing research.

As I learned on my very first trip to the Soviet Union, running clubs are in virtually every city and small town. They call themselves KLBs, which translates to "Club of Running Enthusiasts." They are well organized and each maintains a unique triple focus and function of sports training, fitness, and health, and a place to drink tea and socialize. Each has an elected president whose office places him in the government-sponsored heirarchy of KLB presidents. There are regional and republican officers and a "main man" in Moscow.

This wonderfully organized multitude of running (and walking) enthusiasts makes it easy for visiting fitness runners to make contacts with their counterparts quickly ... a fact which our groups took advantage of on each of our several trips.

During a swing through several Soviet cities in the summer of 1988, I became aware of a veritable hubbub of excitement about a new book on running. In a few short months since its publication, *Chelovek Y Beg* (*Man and Running*) had wowed the Soviet running community as well as the medical community and had sold out. "It is truly a best-seller," I was told. "It is a worldwide literature search!" "It proves the benefits of running and tells us how to train to get the benefits!"

I was sold—but so were all the copies in print! But then came the city of Baku where the president of the entire Republic's running clubs turned out to be a colleague, Aidin Talibov. (Now, the story.) After a "running tour" of the city, Dr. Talibov had arranged a picnic on the beautiful Caspian Sea beach. I believe it was between the caviar and the volleyball that he gathered the crowd for his quiet speech during which he presented me three copies of *Man and Running* "to take home and share with all our American brothers and sisters."

With special thanks to the authors, Drs. Volkov and Milner, and to Dr. Talibov, for preventing a "near miss," the translation which follows represents the execution of Dr. Talibov's exhortation. It flows also from a personal desire to share something very valuable with all my colleagues and fellow fitness runners.

I want to make special mention of a few other Soviet friends and colleagues: Dr. Stanislav Likholetov, immunologist, environmentalist, and marathoner of Volgograd; Dr. Slava Lapin, fitness runner and chief of Leningrad's Psychiatric Research Institute; David Fastovsky, president of Moscow's "Mir" running club; Tengiz Geldiaschvili of Tbilisi, marathoner and holistic healer; Gennadi Kostyanov of Chernigov, engineer, marathoner, and builder of the ill-fated Chernobyl power plant; Sasha Kizil, president of the Minsk running club; and Albert Aminov, geologist, marathoner, and president of "Second Wind" running club in Duschanbe. I acknowledge all of them for their commitment to running as a means of health and well-being—but even more heartily I acknowledge their tireless work in the Peace Movement and the movement to end world hunger.

To assure optimum accuracy, I have commissioned native Russians for the initial translation of this volume. I am personally responsible for the final polished version and the technical accuracy. Criticisms and suggestions for future editions may be forwarded to me through the publisher.

Dan Drew, M.D., A.B.F.P.
Danville, Virginia

Foreword

It is a pleasure for me to write the foreword for this excellent review of physical activity, physical fitness, functional performance, and health. I visited the former Soviet Union in 1989, prior to the installation of democratic reforms in that country, and during the time the iron curtain was still in existence. Although I did not meet Drs. Volkov and Milner on that trip, I did visit a sports medicine institute in Leningrad (now St. Petersburg) and met many sports medicine physicians and exercise scientists. I found them to be warm and friendly and eager to share ideas and research information. I was impressed with their knowledge and enthusiasm for exercise science research, although the lack of resources was a barrier to conducting studies.

I later was pleased to meet Drs. Volkov and Milner in Indiana at a meeting organized by Dr. Dan Drew in 1990. I fondly recall our scientific discussions, a long run on a hot afternoon, and a party with dancing at the banquet of the Indiana Academy of Family Physicians meeting. It was delightful to get to know them as friends, as well as develop respect for them and their scientific accomplishments.

Dr. Volkov, as professor and chairman, and Dr. Milner, as an assistant professor, work in one of the finest sports medicine institutes in the former Soviet Union. They have made important contributions to exercise science and sports medicine in their country, and now with the translation of this book, have the opportunity to share their ideas with a larger audience. The book is an extensive review of a world-wide literature search. It is interesting to contemplate that it was done by persons who were working under considerable logistical handicaps and in a closed society. I hope that you will find their ideas stimulating and would encourage you to correspond with them about any issues related to sports medicine.

Special commendation is extended to Dr. Dan Drew. Dr. Drew became interested several years ago in the Soviet Union. He learned Russian and made several trips to the former Soviet Union during the 1980s with his family. He made many friends, and his contacts with sports physicians led ultimately to meeting Drs. Volkov and Milner and to the translation of this book. He is an excellent example of what a single individual can achieve with perseverance toward a goal. If more of us reached out to our fellows in other countries and tried to break down artificial barriers that frequently exist between people of different nationalities, the world would be a better place. Dr. Drew accomplished this not as a part of an organized group or as a member of a team, but on his own. I admire him for his efforts toward international peace and collaboration with foreign scientists and physicians.

Steven N. Blair
Institute for Aerobics Research

Chapter One
PHYSICAL ACTIVITY AND HEALTH

RUNNING AND DISEASE IN THE TWENTIETH CENTURY

A rising death rate due to cardiovascular disease is a characteristic feature of this century in economically developed countries. These diseases are the result of peoples' markedly reduced motor activity, high calorie nutrition, and excessive strain imposed on the nervous system by the increased flow of information and the recurrence of stress situations.

Widespread death from infectious diseases has been replaced by a wide distribution of ischemic heart disease, unmatched in the past. The death rate for this illness is the highest among all diseases in the world, surpassing even such a formidable foe as malignant neoplasm (cancer). According to the World Health Organization [337], ischemic or "coronary artery disease" (CAD) means insufficient supply of blood and oxygen to the heart muscle resulting from sclerotic damage and stenosis of the coronary arteries. Myocardial infarction (heart attack) is the final stage of this disease.

Ischemic heart disease is most often accompanied by pain of varying location and intensity (angina pectoris). But frequently the disease has no symptoms, and presents itself as the cause of sudden death [345]. According to WHO data [337], the death rate due to ischemic heart disease has risen more than 60% in 23 economically developed countries just in the last decade. In the United States nearly one million persons die annually from myocardial infarction [287].

The annual incidence of myocardial infarction among males has been documented to be 3 per 1,000 population in Moscow, 4.9 per 1,000 in London, and 5.9 per 1,000 in Helsinki. Based on a study of the data, a middle aged male runs a one-in-ten risk of suffering a "heart attack" in the next 10 years [154].

Comparative data on the distribution of coronary disease in different countries may be of some interest. Among males aged 40-59, coronary stenosis and myocardial infarction were documented respectively at a rate of 4.9% and 2.4% in Brussels, 6.3% and 1.5% in the Hague, 2.7% and 3.0% in Milan, and 4.4% and 9.6% in Moscow [291].

Among adult men living in Moscow, the incidence of ischemic heart disease has been found to be 8.6%; and in Leningrad, 12.3% [26]; while, among the adult population of the United States, the incidence has been reported at 20% [317].

In reality, however, CAD has a much greater incidence, since frequently it develops in a latent form and cannot be identified clinically. Almost one half of the patients suffering from coronary stenosis do not seek medical attention [50] and, consequently, these cases are not included in any data.

It should be pointed out that coronary disease is not exclusively a problem of the elderly, as was believed until recently. In a special study, undertaken through a WHO program, autopsy of individuals aged 10-19 revealed the presence of sclerotic plaques in the aorta in 8% of cases and in coronary arteries in 24% of cases. In the age group 20-29, these figures increased to 18% and 30% respectively [327].

Epidemiological studies conducted for a number of years in different countries of the world reveal a close connection between the occurrence of CAD and certain factors of external and internal environment, known as "risk factors." These include, among others: high serum cholesterol, diastolic hypertension, obesity, smoking, unfavorable heredity, insufficient motor activity, and excessive nutrition high in calories.

FAULTY CHOLESTEROL METABOLISM

It is commonly accepted that high levels of cholesterol in the blood (hypercholesterolemia) and an abnormal change in the ratio of its components are the key factors in the development of atherosclerosis and its manifestations—damage to the coronary arteries, brain, and lower extremities [26, 37, 78, 215, 317]. The upper limit for cholesterol content is normally 250 mg% in the USA and Europe, 220 mg% in the USSR.

In the industrially developed countries, the incidence of hypercholesterolemia exceeding the upper limit (250 mg%) was found to be approximately 23% of males over 35 years of age [315]. The well-known American expert on fitness running, Kenneth H. Cooper [122], maintains that middle aged people with cholesterol levels of 240-260 mg% are facing a moderate risk of developing CAD, while the risk is very high at levels over 260 mg%.

The results of the widely known Framingham study (results of 20 years of study conducted on 5,000 residents of Framingham, Massachusetts) indicate that subjects with cholesterol levels exceeding 260 mg% developed coronary disease 2.5 times more often than those whose level was under 240 mg% [204], and 5 times more often than subjects with cholesterol levels under 200 mg%. Thus, among 5,000 healthy people in Framingham, only 45 subjects whose cholesterol levels were below 200 mg% developed coronary insufficiency during the ten subsequent years, while among those whose cholesterol levels were over 260 mg%, 200 persons were affected.

The risk of developing CAD is in direct ratio to the concentration of cholesterol in the blood. A 1% increase in the cholesterol level produces a 2.5% greater risk of coronary disease. This demonstrates the importance of reducing the level of cholesterol in the blood. Experiments on animals, as well as clinical study of subjects suffering from ischemic disease, indicate that reducing the level of cholesterol below 200 mg% may not only check further development of the disease, but may also result in complete disappearance of atherosclerotic plaques [237].

The composition of cholesterol has even greater impact on the development of atherosclerosis. Cholesterol combines with molecules of protein to yield lipo-albuminous complexes (lipoproteins). These include two classes: low density lipoproteins (LDL) and high density lipoproteins (HDL). These have opposite effects on the development of atherosclerosis. LDL has a high percentage of cholesterol and very little protein as such. LDL is definitely atherogenic. It easily penetrates the wall of a blood vessel and eventually forms an atheromatous plaque.

HDL, on the other hand, is mostly protein, with very small content of cholesterol, and is known for its ability to prevent atherosclerosis [89]. HDL is able to absorb the molecules of cholesterol from the vascular wall and transport them to the liver, where these molecules are split, transformed into bile, and excreted through the intestine [248, 249, 288]. Thus the higher is the blood level of HDL, the lower is the danger of developing coronary disease [114, 169].

The proportion of different classes of lipoproteins is usually expressed as the "atherogenic ratio"—the ratio of total cholesterol content in blood to the level of HDL.* The higher this ratio, the higher is the danger of developing atherosclerosis, and vice versa. On the basis of data from the Dallas Center for Aerobics, Cooper believes [122] that the risk of CAD in middle aged males with "atherogenic ratio" below 6.0 is small; with a ratio of 6.0-7.5, the risk is moderate; and with a ratio greater than 7.5, the risk is very high.

An additional factor in the development of atherosclerosis, apart from cholesterol, is the increased level of triglycerides (neutral fat) in the blood. Triglycerides are the major source of free fatty acids, which are important as fuel in the oxidation and the release of energy in muscular activity. The storage of triglycerides in the form of fatty concentrations occurs in subcutaneous cellular tissue and is introduced into the blood during prolonged, though not vigorous, exercise—and also as the result of fasting. The risk of CAD increases directly with increases in blood triglyceride levels. A triglyceride level above 140 mg% indicates a danger of developing atherosclerosis [37]. According to Cooper, CAD can be prevented by keeping the triglyceride level below 100 mg%—or at least, not over 120 mg% [122].

Typical changes in fat metabolism are observed with age, and these changes are conducive to development of atherosclerosis: increased levels of

---

*Other methods for calculation of the "atherogenic ratio" are possible, e.g., the ratio of HDL to LDL [288].

BEST COPY AVAILABLE

cholesterol, triglycerides, and LDL, with a corresponding reduction in HDL [179, 192, 237, 260]. According to the data of a joint research project conducted by Soviet and American scientists [61], disorders of lipid metabolism in males aged 40 and older are as follows.

In the group examined in the USSR, the level of cholesterol, triglycerides, and LDL was, on the average, 10% higher than in the comparable group in the USA. However, research conducted in the USSR reveals that the levels of HDL are 8% higher, and for this reason the occurrence of coronary disease in the USSR is not more frequent than it is in the USA.

There are two ways to normalize lipid metabolism: first, by a low calorie diet, low in saturated animal fats and simple carbohydrates; and, second, by physical training. We shall discuss the benefits of a health oriented diet elsewhere. Meanwhile, we will discuss the impact that physical training has on lipid metabolism.

Many authors attest to the normalization of lipid metabolism as a result of physical training [167, 258, 260]. Recently, S. V. Bogush [15] reported that after completing a 3 month program of jogging 3 times a week for 30 minutes, participants in their middle age demonstrated reduced levels of cholesterol, triglycerides, LDL, and a lower atherogenic ratio. As a result, the number of subjects with abnormal lipid metabolism was reduced to less than half of the pre-exercise number.

American researchers observed a sharp drop in the blood levels of triglycerides immediately after a one hour workout on an exercise bike [133]. All researchers studying the problem report a reduction in cholesterol, triglycerides, and LDL, as well as an increase in HDL as a result of jogging [93, 101, 145, 177, 231, 288]. A study of approximately 4,000 healthy women aged 18 to 65 at the Dallas Aerobics Center revealed that the blood levels of triglycerides, HDL and the "atherogenic ratio" were closely related to the duration of exercise and the fitness of the women. The more fit they were, the better were the parameters of lipid metabolism in terms of preventing atherosclerosis [167]. Besides his own observations, Cooper [122] cites interesting examples from the *Journal of the American Medical Association* regarding the impact of jogging on cholesterol metabolism.

One of the studies observed a group of healthy 60 year old men before and after 12 months of regular jogging for at least 30 minutes 3 or 4 times a week. At the end of this protocol, all the participants demonstrated considerable reduction in the level of LDL and an increase in HDL levels. Another study of lipid metabolism included 750 middle aged men, and revealed a close relationship between physical fitness and the level of cholesterol and HDL. Improved fitness was always accompanied by a clear reduction in the cholesterol level and a lower atherogenic ratio.

Impressive results were yielded by a comparative study of lipid metabolism in 84 men and women aged 35-60 who ran 30 to 60 km a week, contrasted with a control group of sedentary subjects [343].

PARAMETERS	RUNNERS		SEDENTARY CONTROLS	
	Male	Female	Male	Female
Triglycerides	70	56	146	123
Cholesterol	200	193	212	209
LDL	125	113	139	124
HDL	64	75	43	56
HDL/LDL	0.51	0.66	0.31	0.45

Table 1. Parameters of lipid metabolism (mg%) comparing a group of runners with a group of subjects with inactive lifestyles: Wood, 1977 [343].

As is clear from table 1, joggers have "better numbers" in all parameters of lipid metabolism. Subjects who lead inactive lives have twice the level of triglycerides. The ratio of HDL to LDL, the main indicator of risk for CAD, also is much better in the joggers.

A.A. Viru analyzed the influence of various types of jogging exercise on lipid metabolism. He compared the changes that occur in this process in running a 200 meter distance with maximal speed, with uninterrupted running of a 3 km distance at average speed (pulse rate of 170), and in slow running of a 6 km distance (pulse of 140). He discovered that only the third type of running results in reduced LDL and increased HDL, the latter component being responsible for protection from coronary disease. No significant changes in lipid metabolism were found in the first two types of running. Thus, slow and prolonged running is the type of activity which is a reliable means of normalizing lipid metabolism and neutralizing the most important risk factor in the development of coronary artery disease.

HIGH BLOOD PRESSURE (HYPERTENSION)

Blood pressure is considered normal if systolic pressure is lower than 140 mm, and the diastolic is lower than 90 mm. The diagnosis of hypertension (high blood pressure) is defined by a systolic pressure above 159 mm, and/or the diastolic is higher than 94 mm. Blood pressures in the range of 140/90 to 160/95 are considered borderline (between normal and pathology).

In industrially developed countries today, more than 28% of people have high blood pressure [315]. A comparative study, conducted in seven countries, established the following incidence figures for hypertension: Japan, 13.8% of the population; Greece, 12.5%; Yugoslavia, 15.7%; Italy, 22.1%, Holland, 30.3%, USA (railroad workers), 22.3%; France, 20.8%. With age, the number of people suffering from hypertension increases. Thus, according to the data of the U.S. National Institutes of Health, hypertension was found in

13% of males aged 35-44, while in the age group 55-64, the incidence was already 31%. According to the All-Union Cardiology Center, hypertension was found in the USSR (Leningrad) in 64% of males aged 50-59, and in 75% of those over 60 [43].

Various authors indicate that high blood pressure increases the risk of developing CAD 1.5-6 times. A 1% increase in the systolic pressure increases the risk of CAD 2.5-4.5%, depending on the patient's condition [123]. This is understandable especially if one recalls the mechanism of development of atherosclerosis. The higher the pressure, the easier it is for molecules of cholesterol to penetrate the vascular wall, subsequently to damage its internal membrane (intima) and lead to formation of an atheromatous plaque. For this reason, a high level of atherogenic cholesterol (LDL) and hypertension are two major factors in the development of the atherosclerotic process.

A study of middle aged Leningrad males with normal blood pressure revealed an incidence of coronary disease of 16%, while subjects with high blood pressure had an incidence of 31%, i.e., almost twice the incidence [43].

A study conducted in Hawaii [345] to determine rates and causes of death among males examined 595 deaths that occurred over a 10-year period among 8,000 subjects born between 1900-1919. The study revealed that 34% of the deaths were the result of cardiovascular diseases. Furthermore, the presence of "borderline hypertension" (140-159 mm) caused a twofold increase in the death rate from CAD when compared with subjects with normal blood pressure, while full blown hypertension (over 160 mm) increased the death rate 5-6 times. Notably, even with normal blood pressure, the death rate increased proportionately with an increase in blood pressure from 120 mm to 140 mm. With high systolic pressure, the increase in death rate was from myocardial infarction; whereas, high diastolic pressure correlated with an increased incidence of brain hemorrhage.

Recent research [142] has indicated that the likelihood of developing hypertensive disease in subjects with normal blood pressure can be tentatively predicted from the response to a measured "work load" on a bicycle ergometer. If a sharp increase in pressure is observed, the development of hypertension in the next few years is very likely, while a normotonic response to the effort suggests that the risk of developing hypertension is minimal.

Thus, out of 100 Americans over 35 years of age with normal blood pressure readings who showed signs of hypertensive disease during the bicycle stress test (systolic pressure over 200 mm or diastolic pressure over 100 mm), hypertension developed in 8 men during the ensuing 3-10 years. In the control group of males with a normotonic reaction during the stress test, there were no cases of hypertension during the same time period.

Rhythmic exercises (running and others) can significantly reduce or even eliminate the risk of developing coronary disease due to hypertension, since prolonged exercise of moderate intensity causes dilation of the arterial lumen, reduced peripheral resistance, and lowering of blood pressure [17]. Many authors attest to a reduction in blood pressure caused by rhythmic exercises [247, 306, 335, et al.]. Penny [278] observed a reduction in blood pressure in 13 healthy untrained males over age 35 after completing a 14 week fitness program that involved 3 sessions a week of 30 minutes. Each session began with a brief warm-up followed by a 2 mile run. At the end of this protocol, average systolic pressure fell from 132 mm to 124 mm, and average diastolic from 86 mm to 81 mm.

OBESITY

Obesity is defined as having a body weight above normal. If body weight exceeds the norm by more than 10%, an individual is said to be obese. Various formulas or tables are used to calculate normal weight (e.g., the height-weight index of Brock). As a result of excessive nutrition and low physical activity, 40 to 50% of the adult urban population in economically developed countries suffer from obesity [89]. Among middle aged men in Moscow, an incidence of obesity of 34% was found. In the USA, the incidence is 25% of the entire population.

Obesity is an additional factor in the development of coronary disease, for obesity is frequently accompanied by high cholesterol and high blood pressure! A study of middle aged males in Finland established a close relationship between the index of body weight and lipid metabolism. Subjects with a normal "weight index" (up to 23 kg per square meter of body surface) had normal levels of triglycerides, LDL, and HDL. When the index increased over 26, all the lipid values worsened proportionately to the weight increase [224].

A study of two large groups of middle aged persons, a group with normal weight and a second group 25% above normal, demonstrated a considerably higher level of triglycerides and atherogenic cholesterol (LDL) and a lower level of HDL in the obese group compared with the group with normal body weight [343]. According to various authors, obesity increases the risk of coronary disease from 1.3 to 3.4 times, primarily by predisposing to coronary stenosis and sudden cardiac death [204, 315]. The Framingham study also confirmed that coronary stenosis and sudden cardiac death occur in obese subjects more frequently than in persons with normal body weight [204].

A group of American researchers headed by Rossi [293] conducted an interesting experiment that involved three women whose weight was an average of 80% above the norm. The women walked approximately 111 minutes a day at a speed of 3 miles per hour. At the same time, they were offered an unlimited choice of tasty low calorie food. With this regimen, the energy consumption was only 1,900 kilocalories a day, while energy expenditure was 2,800 kilocalories, i.e., the energy expenditure considerably exceeded the energy taken in with food. After 60 days of this program, the average weight was reduced from approximately 100 kg to 93 kg.

As recent studies by Duran and colleagues demonstrated [147], systematic physical exertion causes weight loss not only by increasing energy (calorie) consumption, but also by suppressing the feeling of hunger and appetite. Moreover, this phenomenon is more pronounced in the obese than in lean persons.

Prolonged jogging is the best way to lose excessive weight. According to the data of the New York Academy of Sciences [343], regular jogging helps to maintain ideal weight until very advanced age. A study of two groups of middle aged subjects, one running regularly at least 28 km a week, and another leading inactive lives, demonstrated that the weight of joggers was nearly ideal and their body fat content was 1.5 times less than that of their inactive counterparts (table 2), whose average weight exceeded the norm by 25%.

PARAMETERS	RUNNERS		INACTIVE	
	Male	Female	Male	Female
Weight at time of study	71	57	81	66
Weight at age 18	68	57	68	55
Maximum lifetime weight	81	64	87	71
% body fat	13	21	21	35

Table 2. Comparative body weights (kg) and percent of body fat in joggers and sedentary subjects: Wood, 1977 [343].

SMOKING

The majority of scientists believe that smoking increases the risk of myocardial infarction, for nicotine causes spasm of the coronary arteries, slows down blood circulation, and invites the possibility of occluding blood vessels by formation of blood clots (thrombus). Studies by Soviet anatomical pathologists show that severe stenotic damage to the coronary arteries is 2-3 times more frequent in smokers than in nonsmokers [2]. Unfortunately, smoking is widely popular all over the world.

Smoking increases the danger of myocardial infarction 1.5 to 6.5 times depending on the number of cigarettes consumed [315]. Analysis of statistical data from 21 countries indicates a relationship between the number of cigarettes consumed per adult and the death rate from coronary disease [256]. It is not surprising that recent research demonstrated a close inverse relationship between the intensity of smoking and the levels of HDL which has a protective anticoronary-stenosis property. The greater the number of cigarettes smoked, the lower is one's HDL.

Nicotine has such strong atherogenic properties that it totally neutralizes the benefits of physical training in improving lipid metabolism in CAD patients. Thus, among 40 CAD patients in London's Queen Elizabeth Hospital undergoing a 3 week rehabilitation program that involved slow jogging 20-40 minutes a day, 34 subjects who stopped smoking demonstrated a sharp increase in their HDL levels and a lowering of the atherogenic factor, while 6 other subjects who did not abandon the habit, showed no change in their lipid profile [132].

Yet, though ineffective in this respect, physical training can be successfully used in preventing coronary disease in smokers as well, for it makes breaking the habit considerably easier for people determined to do so. A number of studies attest that regular jogging results in reduced cigarette consumption, while in many cases it brings about a complete breaking off from the counter-productive habit [146, 307].

Quitting the smoking habit, together with regular physical training, can markedly improve the physical condition of even the most addicted smokers. The Framingham study has shown that after 5 years, persons who quit smoking face the same risk of developing coronary disease as those who never indulged in this "luxury" [204]. So, smokers, take heart!

OMINOUS HEREDITY
(BAD GENES)

Heredity is the only factor that cannot be totally neutralized, for one does not choose one's parents. A higher risk of acquiring coronary disease exists if one of the immediate ancestors died from myocardial infarction before the age of 50. However, Cooper [121] believes that the way of life of the ancestor suffering the heart attack should be taken into account. If the person was not obese, did not overeat or smoke, was physically active, and still died from a heart attack in spite of a Spartan lifestyle, then the descendants indeed face a greater risk of acquiring coronary disease than people with favorable heredity.

On the other hand, if a person's hobby is cooking, he/she is corpulent and spends hours on end watching television with a cigarette in mouth, an early death might not be so surprising, and it would not be false to say that they voluntarily shortened their own life. In such cases, a premature heart attack ought not be blamed on unfavorable heredity, believes the director of the Dallas Aerobics Center.

Heredity provides not only a negative influence, but a positive one as well, since it can be a factor of genetic defense against development of coronary disease. The Pima Indians of Arizona lead, in modern terms, a typically inactive life, eat mostly high calorie foods, and suffer from obesity and diabetes, yet cardiovascular diseases among them are 7 times more rare than the national average. Researchers see the reason for this in the fact that the Indians are found to have low levels of atherogenic lipoproteins (LDL) and high levels of HDL, inherited from their ancestors who for centuries had led an extremely active life. Similarly, a negative ratio of high and low density lipoproteins can be genetically inherited, presenting a higher risk of developing coronary disease.

The majority of scientists believe that the combination of external factors (nutrition, physical exercise, and bad habits) prevails to a great extent over the impact of heredity. Epidemiological study of over 2,000 pairs of monozygous male twins revealed a co-occurrence of infarction only in a limited number of cases; while the majority of those who had suffered the infarction were much less active in their free time and psychologically less stable under stress than their discordant brothers [235].

Thus, the possibility of inheriting a heart attack should not be looked upon as a fatal inevitability. A much better approach would be to make radical changes in lifestyle, abandon bad habits, and replace TV watching with fitness exercises. Then there will be no reason to blame fate, doctors, or "bad" parents!

Besides the biochemical makeup of our blood, hereditary factors can also include personal psychological features that condition the reaction of a person to external stresses. There are two well known types of people with different "psychological profiles"—type A and type B, as proposed jointly by Friedman, director of the Harold Brown Institute in San Francisco, and Rosenman.

Type A is characterized by the so-called "coronary profile," i.e., increased reactivity of the nervous system under the effect of negative irritants. In other words, this type has reduced stability under the influence of stress factors and is more exposed to the risk of myocardial infarction than type B. The type A person is known for constant striving after unclear goals, an inflated sense of leadership, restlessness and nervous tension, constant time urgency, suspiciousness, and psychological instability. A drastic change in life circumstances (such as retirement, divorce, or death of a spouse) can serve as a powerful stress factor and can accelerate infarction.

However, being type A does not necessarily mean that a person is doomed to infarction. Physical training, especially endurance exercise (jogging, skiing, etc.), is the best way of normalizing the functioning of the central nervous system, reducing excitability and nervous tension. Running is the best method of neutralizing the psychological stress, or to put it differently, "knocking out" psychological stress and displacing it with a physical stress.

Psychological factors are among the most important in the development of myocardial infarction. Stress irritants cause excessive secretion of hormones from the adrenal glands, adrenalin and noradrenalin, which put the body into the "ready for action" state. Our ancestors used to neutralize the effects of these hormones on the cardiovascular system by using appropriate motor reactions—escape, attack, or defend. We, however, have a much more constricted range of choices.

The combination of several risk factors in a given individual is especially dangerous. 90% of middle aged males in Moscow have at least one risk factor, and 50% have two or more of these factors [26]. The presence of one risk factor increases the danger of heart attack 2.5 times, while numerous risk factors combined can increase the risk as much as 10-11 times.

Thus a study conducted in Samarkand revealed an incidence of coronary disease of 1.6% in subjects without risk factors, while the incidence increased to 4.4% with 1 risk factor; 11.4% with 2 risk factors; 18.4% with 3 risk factors; and over 20% with 4 risk factors.

Epidemiological study of the population of the USA also indicates a 10 fold increase in the incidence of CAD when risk factors are combined [89]. For example, the data generated by a national study in the USA [153] demonstrate three risk factors (hypercholesterolemia, hypertension, and smoking) as having the following significance for prediction: A combination of two or three factors was found in almost 40% of male subjects, and this group had a 60% share of all cases of coronary disease and sudden death. With one risk factor, myocardial infarction occurred with an incidence of 48 per 1,000 over a period of 10 years; while two risk factors generated an incidence of 90 per 1,000; and the presence of three risk factors increased the incidence to 117 cases per 1,000. When all three factors were absent, the incidence of myocardial infarction was reported at 10 per 1,000.

But even with such formidable odds as a combination of three major risk factors, the development of coronary disease can and should be attenuated or arrested. This can be achieved by prolonged jogging, since regular endurance exercise neutralizes partly, or even completely, such damaging factors as hypercholesterolemia, hypertension, and obesity, as has been demonstrated, assisting at the same time in breaking the habits of smoking and overeating. And the sooner you start running, the better are your chances of avoiding a heart attack.

INACTIVITY AND OVER-EATING
THE "COUCH POTATO SYNDROME"

So, what are the main reasons for major risk factors in the development of coronary insufficiency? Limited motor activity (hypokinesis) and excessive, high calorie diet are the two "enemies" of the human race responsible for the majority of diseases in our civilization. These two factors combined cause disorders in lipid metabolism, weight gain, and hypertension.

In the 30 years since publication of the classic work by Morris and co-authors [253] on the effect of sedentary lifestyle on development of myocardial infarction, the issue has been extensively studied. Hypodynamism (insufficient activity) is a major cause for the increased number of cardiovascular diseases in the last 50 years. This fact is attested by a vast number of studies that demonstrate great contrast in the frequency of coronary disease between subjects engaged in physical labor and those living sedentary lives.

Conclusive evidence for the relationship between coronary disease and physical exercise is provided in a study that demonstrates close correlation of death rate from myocardial infarction and the number of automobiles per 1,000 people in a given country. The lowest death rate from myocardial infarction has been documented in Japan, a country with the smallest number of private vehicles; while the highest death rate is in the USA, the most motorized country in the world (see figure 1).

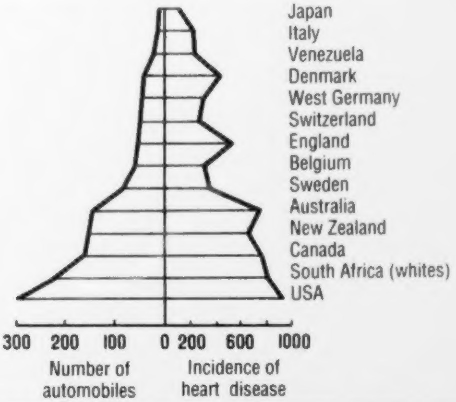


Figure 1. Graph comparing the incidence of death from cardiovascular diseases with the number of private vehicles in different countries.

Joint studies in the USSR, Sweden, and Czechoslovakia within a World Health Organization program indicate a much lower incidence of atherosclerosis of the aorta and coronary arteries, as well as a lower incidence of myocardial infarction, in subjects engaged in hard physical labor, than in persons living sedentary lives [20].

The danger of developing coronary disease as a result of hypodynamism is much higher for persons engaged in intense mental activity. In this group, the frequency of coronary artery disease and myocardial infarction is nearly twice as high as in persons performing other types of professional activity. Thus, according to the research of Cassel and Heyden [113], the death rate from coronary disease among engineers and scholars is 7.3% while it is only 4.0% for persons not involved professionally in mental activity.

Scientists perceive the reason for this is a severe disorder of lipid metabolism resulting from high neuro-emotional tension that is accompanied by increased secretion of adrenalin and noradrenalin that are not utilized or neutralized by physical activity. In other words, intensive mental activity in this case is tantamount to an emotional stress that overtaxes the nervous system and causes disorders in its regulating mechanisms [69].

Interesting data have been gathered in five years of observations of a group of 420 middle aged male engineers in Leningrad, all engaged in intensive mental activity and without noticeable signs of coronary disease. At the end of the observation period, typical features of coronary disease, both clinical and EKG, were detected in 140 of them. Moreover, the number of engineers with cholesterol levels above 270 mg% increased three-fold since the beginning of the observations. At the same time, the number of males with cholesterol levels below 200 mg% dropped, and they also had a concentration of HDL (protective lipoprotein) 10% less than the average for males in Leningrad [72].

Recent studies by American scientists [193] have shown that after four months of conscientious jogging 3 times a week for 60 minutes, males over 40 engaged in intensive mental activity demonstrated significant normalization of lipid metabolism, increased mental efficiency, and improved capacity for information processing. At the same time, their colleagues who maintained a sedentary lifestyle (the control group) did not improve in any of these categories.

Physical training is most effective when combined with a sensible diet, since diet also affects the risk of developing coronary disease. Scientists agree that a high-calorie diet rich in cholesterol is a major factor in the modern epidemiology of coronary disease. The reason for this is a close correlation between the dietary intake of cholesterol and the blood cholesterol level. The higher the dietary cholesterol intake, the higher is the blood level.

Apes that were fed with food containing large amounts of cholesterol (600 mg a day) developed severe atherosclerosis of the aorta and coronary arteries after only a few months [83]. In humans also, high levels of cholesterol in the diet lead to its increase in the blood.

A study that involved a group of middle aged men and women in Finland [151] began with a documented daily intake of 2,900 kilocalories (of which 126 grams or 1,170 kilocalories were fats) and initial average cholesterol of 263 mg%. After a 6 week course of an antisclerotic diet with reduced calories (2,400 kcal) and animal fats (65 grams or 539 kcal), substitution of oil for butter and lean meat for fat meat, as well as increased consumption of fruit and vegetables, the cholesterol level in the group dropped to an average of 201 mg%. Consequently, the danger of acquiring coronary disease was reduced 5-6 times for these volunteers. However, when the participants of this experiment resumed their usual diet, the cholesterol level returned to 260 mg% after only one month.

Blumenfeld [103] cites in his book, *Heart Attack, Are You A Candidate?* an interesting example in support of the impact that an anticoronary diet has along with minimal increase in physical exercise. In 1958, the Anticoronary Club was opened in New York. Norman Jolliff, the club's initiator and director of the New York Nutrition Bureau, offered 400 members a special program for fighting atherosclerosis. The terms of this experiment stipulated that every club member commit himself to a special diet and a physical exercise program of daily walks, as well as to a weight loss goal. Those who would not keep these terms were required to leave the program. Only a few did not stay in the program.

"Sensible diet" (the term proposed by the author of the experiment) consisted of reduced consumption of fat meat, eggs, and butter. These were replaced with vegetable oil, lean meat, fish, vegetables, and fruit. The diet also excluded any "pure" calories (sugar, pastry, etc.). As a result of this radical restructuring of diet, all the participants demonstrated positive changes in lipid metabolism: lower cholesterol and LDL, as well as higher HDL levels.

The results of the experiment exceeded all expectations. According to the data of the Framingham study where the participants were assigned only a passive role and their lifestyle remained unchanged, researchers expected 25 out of 400 subjects to develop coronary disease. Yet at the Anticoronary Club only 4 members were affected by coronary disease. Thus the danger of coronary disease was reduced six-fold as a result of adopting a sensible diet and daily walks.

Although more than 25 years have passed since that remarkable experiment, the anticoronary diet is still not outdated even today. At present, N. Pritikin's diet [283], in principle not different from the diet developed by Jolliff, is highly popular in the USA. It is based on complex carbohydrates in the form of fresh fruits, vegetables, and cereals (80%), combined with limited amounts of protein and fats (10% each).

Vigorous physical training, combined with a sensible diet, is the only way to effectively combat the "coronary epidemic." The impact of these two major anticoronary factors has been conclusively demonstrated in studies sponsored by the World Health Organization in a number of countries. A well known fact is that in Africa and Southeast Asia, where food shortages are common and people lead active lives, heart attack is virtually unknown [89]. For example, in 6,500 autopsies performed in Uganda in the last 25 years, damaged coronary arteries were not discovered even once! Coronary disease is similarly rare in China, where the population is physically active and the diet consists mainly of produce.

And it is not only in the countries of the African continent that the impact of physical activity in preventing coronary disease has been clearly seen. An interesting experiment was staged by nature herself. In Switzerland, the death rate from heart attack is as great as in other European countries. Yet residents of the small Swiss town of Blattendorf, located high in the mountains, are isolated from the outer world and must make daily trips on foot to the neighboring communities in order to get food. As a result, coronary disease is virtually unknown among them [103].

RUNNING AGAINST CANCER

In recent years, much evidence has appeared that running is effective not only in fighting atherosclerosis, but also in preventing cancer. First to arrive at this conclusion was a well-known doctor and trainer, Ernst van Aaken, who specializes in fitness running. Observing a group of 500 runners and an equal number of inactive subjects, he discovered that over a 4 year period, 4 persons developed cancer in the running group. After their operations, all of them had rapid recoveries and returned to the group. During the same time, in the control group, 18 persons had cancer and half of them died. The explanation of the protective effect of running over cancerous diseases is that the overall immunity of the body increases due to exercise because of an increase in the activity of lymphocytes which destroy cancer cells.

The experiments of Rush and Hofmann with animals [cit. ex Cooper, 122] demonstrated that forced running on the treadmill stopped the growth of cancerous cells. Studies of human populations have also yielded encouraging data. Paffenbarger [275] has observed more than 16,000 males over 16 years. In a group with limited physical activity (energy consumption for physical exercise less than 500 kcal/week) 26% developed cancer. In a second group, with more vigorous physical training, only 19% developed malignant neoplasm. The difference is not great, but energy consumption in the more active group was also much less than optimal.

These observations find additional support in the newest studies of a large team of Soviet scientists led by V. P. Mishchenko [51]. It is known that malignant cells can develop when the genetic apparatus of a cell, located in the DNA molecule, has been damaged. Such damage can be caused by cancer-causing elements that are present in the body in the form of toxic oxides, most actively produced as an effect of hypodynamism. Yet normally in a healthy person, these toxic compounds (free radicals) are neutralized by special mechanisms of antioxidant defense. The reliability of this defense depends on the level of antioxidant elements (glutation) in the blood and the proper activity of the enzyme superoxide-dismutase.

A study of 126 runners over 40 years old found that the level of these elements in blood and their activity were much higher in runners than in subjects not involved in running. Stability of erythrocytes subjected to the damaging effect of toxic oxides was also higher in runners than in the control group. Furthermore, positive changes in the body's system of anti-tumor defense were directly proportional to the length of time the subject had been running. Accordingly, the sooner one starts a program of fitness running, the greater will be one's body's stability against cancer.

RUNNING AND LONGEVITY

You have already learned about such wonderful powers of fitness running as the capacity to neutralize major risk factors of coronary disease and reduce the risk of death from myocardial infarction, and even to provide protection from cancer. Running against cancer—running against arteriosclerosis—where else can one find such a remedy?

Do these facts give us the right to venture a definite answer to the sacred question of whether running prolongs human life? Unfortunately, no conclusive scientific evidence in support of this theory has been obtained as yet.* Only a few studies suggest a longer life span for physically active people. For instance, Bulier [16], in studying the longevity of students at Cambridge University, established that the average age at death was 67.97 for subjects who engaged in sports, while the figure was 67.43 years for the presumably less active nonsportsmen.

In all fairness, we must admit that some researchers doubt the impact of physical training on both longevity and the incidence of coronary disease, as well as its impact on the death rate from myocardial infarction. Thus, in 1972, Froelicher and Oberman [166] published a critical analysis of 35 reports by various authors on the role of inactivity as a risk factor in developing coronary disease, but could not assert an opinion because of the contradictory nature of the results.

The most comprehensive study of this issue, done by the American epidemiologist, Keys [215] together with researchers from six other countries, has not established any dependable correlation between sedentary life and the incidence of coronary disease. The inconclusiveness of these studies is apparently due to the following reasons:

First, it is difficult to determine with precision who is sufficiently active in day to day life, and who is not. Data from a poll, performed in a segment of a population, or even within an entire country, have been completely invalidated by a subsequent meticulous examination, for more than half of the participants contradicted their own initial answers. Thus, for example, in a large group of middle aged men who died from heart attack, only one out of five considered himself physically inactive. However, their widows reported their late husbands to be insufficiently active in half of the cases [215].

---

*Experiments on rats indicate that animals bred in an environment of optimal physical exertion live 10-15% longer, as compared with control animals.

Second, even allowing that a comparative study of different professional groups (e.g., bus drivers and conductors) is valid, still these supposedly "active" people do not, in fact, receive enough physical exertion, since it is not sufficiently vigorous [89]. Ordinary motor activity in modern society does not involve enough muscular resistance or stimulation of the circulatory system. One can work an entire day at a lathe or sell tickets on a bus, but this will correct only hypokinesis (lack of movement) and will not eliminate hypodynamism (lack of muscular exertion), which is the main cause in the development of coronary disease.

American cardiologist Raab has justly called the heart of modern man an "active idler." Lack of hypokinesis alone does not prevent the development of coronary disease, because only exertion with a pulse of 120 beats per minute is effective in preventing the disease. However, in modern society, even very vigorous activity only rarely provides sufficient stimulation of cardiac performance. Continuous ECG recording during a 24 hour period demonstrated that the frequency of heart contractions (systole) in the course of a work day does not exceed 90-100 beats per minute, which is far from being sufficient for the prevention of coronary disease [135].

In short, ordinary day to day activity of modern man has no perceptible "anticoronary" effect, because of its limited intensity. This fact was very appropriately expressed 20 years ago by R.T. Shephard, one of the directors of the Rehabilitation Center in Toronto: "Possibly only very intense exercise is effective in the prevention of coronary disease, since only a pulse rate of 120 or higher, maintained for reasonable duration of time, is a sufficient training stimulus for activating compensatory mechanisms of the cardiorespiratory system" [311].

T.N. Morris from Britain [254] points out that running for 20 minutes produces a physiological effect different from a 2 hour walk. People leading a so-called "active" life due to the requirements of their profession and those who engage in physical training in their free time are two very different groups with respect to the prevention of coronary disease. For this reason, there is special importance in the studies of the role of motor activity in the prevention of coronary disease through free-time physical training that can provide the right kind of intensity.

One such study, for example, by Soviet V. M. Zatsiorsky, demonstrated that physical exercise at work caused only a 10% decrease in the myocardial infarction death rate, while physical exercise performed in free time reduced the death rate 3.5 times.

As can be seen in table 3, death rate among subjects with moderate physical exercise in their free time was only half that seen among sedentary subjects, while there were no deaths in the group with high physical exercise.

In 1984 the results of a 16-year study of 17,000 Harvard University graduates were published. Among subjects who regularly engaged in physical exer-

DEATH RATE PER 1,000	SEDENTARY LIFESTYLE	MODERATE EXERCISE	HIGH EXERCISE
Overall	20.6	10.6	0
From Coronary disease	7.5	4.0	0

Table 3. Relation between physical exercise in free time and death rate per 1,000: (V. M. Zatsiorsky, 1985).

cise, the coronary death rate was two times lower than among their inactive colleagues [122].

Finally, the third factor that determines the effectiveness of physical training is the character of muscular exercise. It is not immaterial what kind of exercise is performed if one wants to prevent coronary disease and prolong life. The hard physical labor of a miner, a lumberjack, or a dock-worker may not only fail in preventing coronary disease, but may even facilitate development of the disease because this exertion is not accompanied by normalization of cholesterol metabolism and reduced blood pressure.

On the contrary, these labors can even increase the level of cholesterol and its atherogenic fractions. This is possibly the reason why Finnish lumberjacks, whose diet contains large amounts of animal fats and cholesterol, have the highest coronary death rate in the world, in spite of their vigorous physical exertion and high energy expenditure. Their coronary death rate is even higher than among American railroad workers [89, 151].

A substantially different effect is achieved by rhythmic exercises that develop endurance—running, skiing, swimming, and bicycling. Prolonged rhythmic exercise of low intensity provides burn-up of dietary fats, thus preventing excessive accumulation of cholesterol in the blood. Moreover, this type of exercise considerably expands a person's capacity to assimilate oxygen—and this cannot be said of power (anaerobic) exercises.

Therefore, only valid contrastive studies of large groups of subjects leading sedentary lives vs. groups who have done long term conscientious endurance exercise can provide conclusive evidence regarding the correlation between coronary death rate and longevity.

Former athletes cannot be assumed to be "physically active" because, after discontinuing sports activities, the changes caused by age (atherosclerosis, etc.) develop even more rapidly than in people who did not participate in sports in their youth [24, 25]. It seems, therefore, that the comparison should not be made between athletes and nonathletes, but between subjects who lead a sedentary life and those who perform rhythmic exercise consistently in the course of their lives. However, studies of this type do not exist, because fitness running became popular only some 15-20 years ago. Apparently, the final decision on the question of whether running prolongs human life will have to be postponed till the next century.

Yet there are some studies even now that indicate a correlation between fitness running and reduction of coronary death rate, as well as increasing longevity. Morris [254] studied nearly 18,000 males who engaged in free-time rhythmic exercise—jogging, skiing, swimming, or bicycling. Observations over a long period of time show that in this group, coronary disease is only half as common as in a sedentary population, while the death rate from heart attack is three times lower. (See table 4.)

	ACTIVE GROUP		CONTROL GROUP	
	Cases Observed	%	Cases Observed	%
Heart attack causing death	24	1.1	411	2.9
Heart attack with recovery	42	2.0	750	4.0
TOTALS	66	3.1	981	6.9

Table 4. Frequency of myocardial infarction among middle-aged males and its correlation with free-time rhythmic physical exercise: Morris, 1980 [254].

Cooper [122] has an interesting observation in his book, *Running Without Fear.* Three thousand runners, who had logged a total of over 1.5 million miles, had been observed for more than five years. During this time, only two cases of heart attack were documented, both with recovery. This is significantly fewer than the number of heart attacks among middle aged people who do not run. This leads the author to conclude that running must have a considerable protective effect against coronary disease.

The result of preventing premature death from heart attack is that vigorous physical training extends the number of years of life beyond the potential heart attack to the limit set for man by nature. In other words, purposeful physical training enables man to realize more fully the extent of life inherent for the human race as determined by the genetic instructions in our DNA molecules.* Researchers believe that physical exercise extends life by at least 8 to 10 years [89, 188].

This view is supported by the newest data on reduced death rates from cardiovascular diseases in the USA, Canada, Japan, and a number of European countries, where populations have radically changed their lifestyles and are beginning to adhere to the new teaching about fitness running and to reduce their dietary animal fats. (See table 5.)

---

*Though recognizing the significance of genetic factors in determining longevity, we do not share the view of G. Celliet about genetically programmed energy storage that allegedly determines the extent of life. According to this approach, life is compared with a wound up clock: as long as the spring is being uncoiled, life goes on. This mechanistic theory of fatal predetermination of life, in fact, discounts the healing effect of physical exercise and a sensible conditioning program.

Thus, in the last ten years, the coronary death rate in the USA has dropped from 511 to 424 per 100,000 as a result of mass "anticoronary" measures (fitness running and altered diet). During this time, the number of American adults who engage actively in physical exercise has grown from 25% to 59% [185]. According to the Gallop poll, almost 35 million people jog and 40 million swim in the USA. In Japan, there are nearly 20 million fitness runners, and the life expectancy in Japan has increased by 20 years in the past 30 years [227]. Equally great are the numbers of fitness runners in France, West Germany, Canada, Australia, New Zealand, East Germany, China, the Scandinavian countries, and Great Britain. The number of fitness runners worldwide today is estimated at 100 million [32].

COUNTRY	DEATH RATE PER 100,000		PERCENT CHANGE
	1968	1977	
USA	864.7	669.5	22.6
Australia	843.7	683.1	19.0
Japan	126.3	102.6	18.0
Canada	703.3	624.1	11.3
Norway	582.9	537.1	7.9

Table 5. Changes in death rates from cardiovascular diseases in several countries from 1968 to 1977. WHO data: V.M. Zatsiorsky, USSR, 1985.

In discussing the effects of running on longevity, the issue of possible serious complications in the cardiorespiratory system, including sudden death, should be addressed. In order to be objective, we want to deal with the subject of "running toward heart attack."

The majority of researchers believe that the possibility of sudden death during a running session is very small; and, in any case, smaller than for sedentary subjects. Even very great physical strain cannot cause death for a healthy person [269]. However, for cardiovascular patients, the danger of complications increases directly with an increase in the intensity of exercise [329]. According to statistical data, 10 to 20 people out of 2-3 million runners die while running [227]. Even though rare, what are the reasons for these casualties in runners?

The main danger is, undoubtedly, coronary artery disease with serious occlusion of the coronary arteries. This cause is the leading one in 75-80% of all cases of death [225, 321, 322, 328, 331]. The most common cause of sudden death at a young age may be myocardial hypertrophy, resulting from inadequate physical work load [243, 268]. Sugishita and colleagues [318-A] conclude that, most often, sudden death occurs during marathon and walking competitions (in 53% of cases) or immediately at the finish (41%).

In runners with mitral insufficiency, cardiac arrest can result from arrhythmia [177] or spasm of the coronary arteries because of excessive secretion of adrenalin and noradrenalin [111, 137]. The role of arrhythmia in cases of sudden death has not been conclusively determined yet. Pantano [276] and Pilcher [281] took continuous 24 hour electrocardiograms of amateur fitness runners and healthy sedentary subjects. Various types of arrhythmia were observed in 75% of healthy people. Cases of sudden death during the Cooper (12 minute) test as well as from sun stroke during a running exercise have been reported [227, 322].

It must be pointed out that abiding by the principles and rules of training for middle aged people will eliminate the likelihood that running will become a cause of sudden death. The risk of sudden death during running is almost negligible and presents danger only for patients with severe atherosclerotic damage of the coronary arteries, when there is no medical supervision, and the principles of training are not observed.

RUNNING AND WORKING CAPACITY

Not only does running prevent premature heart attacks and prolong life, but it also increases working capacity and other vital functions. The question of how one will live the rest of his or her life is never a trivial question. One's future can be a "golden age" or it can become a demonic experience, inflicting unbearable suffering upon patients and their loved ones.

Fitness running is precisely the key to preserving health and remaining alert both physically and mentally until very advanced age. The reason for this is the rejuvenating effect that jogging produces. Besides and beyond a person's chronological age, as indicated on an ID card, for example, there is also a biological age that reflects the functional status of the body. One can be decrepit and senile already at 40-50 years, or remain active in all functions till very late in life. Researchers agree that the key indicator of aging is physical working capacity, which declines with age. In the time span between 30 and 70 years this capacity drops approximately 35-40%. "If there is any way to check the decline of working capacity, that would mean postponing the aging process," said the well-known American, James Fixx, in his *Encyclopedia of Jogging*. He believed that vigorous physical effort in free time (i.e., running) is a most effective factor in promoting longevity.

Throughout the world, the most common way to determine physical working capacity is the PWC_{170} test—measurement of working capacity at a pulse rate of 170. The capacity is measured by the extent of work in kg/min that the subject can perform with a pulse rate of 170. The test is performed on a special bicycle ergometer (or treadmill) that measures the work performed. The higher is the amount of work performed, the higher will be the working capacity rating. For example, for patients recovering from myocardial infarction, the figure could be a mere 300 kg/min, while young and healthy but untrained males show a rating of 1000 kg/min, and professional athletes—runners and skiers—achieve 2,000 - 2,500 kg/min. Sedentary subjects demonstrate a decline of physical working capacity as they advance in age.

Fitness running prevents the decline of working capacity induced by age. D. F. Chebotaref and co-authors [71] studied a large group of males over 60 who had attended a jogging club for a long time, and a similar group of healthy sedentary subjects of the same age. (See table 6.)

PARAMETERS		AGE GROUPS		
		60-69	70-79	80-89
PWC_{170} Test	RUNNERS	852	690	570
	SEDENTARY	660	528	432
Oxygen utilization at maximal effort	RUNNERS	37	30	28
	SEDENTARY	30	26	23

Table 6. Data on PWC (kg/min) and oxygen intake (ml/kg min) for elderly males: runners (group 1) and sedentary (group 2): Chebotarev et al., 1984, USSR [71].

The table shows that fitness runners demonstrated considerably higher PWC and oxygen intake than their sedentary counterparts. Runners in the age group 60-69 years had higher PWC_{170} ratings than subjects 40-49 years old who had never engaged in running (852 kg/min versus 784 kg/min). These data indicate better preservation of functional physical capacities for the runners. Indeed, researchers believe that long distance running postpones the aging process by 10-20 years [188].

We have also documented a significant increase in PWC resulting from regular fitness running. The PWC_{170} test was conducted for 64 female subjects aged 30-60 years (table 7). Analysis of the data shows that the number of years of training and the distance per week are leading factors in increasing PWC. As a rule, the greater the number of kilometers per week, the higher is the rating on the PWC_{170} test. *

The correlation between the PWC_{170} test and age is less obvious. Thus, for example, the highest PWC rating among women was found in runner N. S., age 58 (1,408 kg/min), who runs 30-40 km per week; while V.T. (32 years),

---

*It does not follow from the data that only high effort yields results. We believe that a sensible training schedule, combined with measured periods of rest, are the essential conditions for increasing working capacity.

TRAINING PERIOD & WEEKLY DISTANCE	PWC$_{170}$	
	kg./min.	kg./min./kg.
Under 3 mos. or 9 km/wk	485	8.2
1-2 years or 10-15 km./wk.	780	12.6
3-5 years or 20-30 km./wk.	1086	16.9

Table 7. PWC ratings for women correlated with the time spent in training and the intensity of their training: Observations of Volkov & Milner, authors of this volume.

who was second on the test (1,225 kg/min), did weekly workout schedules of less than 20 km.

Fifty year old males at a local jogging club achieved a rating of 1,500 kg/min on the PWC$_{170}$ test, i.e., the same as for 20 year old physical education students who are involved in nonrhythmic (anaerobic) sports (soccer, fencing, etc.). Younger runners, aged 35, achieve a rating of 1,700 kg/min—same as for the first category of athletes who run long distances!

E. A. Pirogova [55] observed 580 runners aged 30 to 70 years, whose training experience ranged from 1-50 years. Figures for cardiorespiratory function— pulse, blood pressure, ECG—were the same for both old and young! Even such an important factor as coronary blood flow (the amount of blood that passes through the coronary arteries in 1 minute), which is a reflection of coronary artery disease, was not lower for the older subjects. Beginners in jogging had increased their myocardial contractility and improved cardiac efficiency already in the first 8 weeks. As a result, their PWC$_{170}$ ratings increased by 30%. These changes were accompanied by a 25% increase in coronary blood flow and oxygen supply to the myocardium.

Improved function of the myocardium has been confirmed by modern methods of research, since ultrasound (echocardiography) now enables us to determine with precision the size of the heart and its performance in a living human being. British scientists Shapiro and Smith [309] observed a mass gain of the left ventricle due to the thickening of its dorsal wall and interventricular septum in 15 middle aged volunteers (nonathletes) after a 6 week training program that involved moderate running 3 times per week for 30 minutes. These changes were accompanied by increased performance of the heart and its capacity to assimilate oxygen.

It should be pointed out that these exercises did not induce an increase in the size of the heart and its cavities, as is the case with athletes. This mode of adaptation to training efforts is optimal with respect to increasing conditioning and maintaining health [25].

Studying the effects of fitness running on heart function in middle aged subjects, other authors [279] obtained similar data. Unlike the case of pathological hypertrophy (e.g., in hypertensive patients), the increase in the mass of the myocardium of the left ventricle occurs along with coronary dilation and an increased coronary blood flow. The American marathon runner de Mar, who died at the age of 73, had a coronary artery diameter 3 times wider than a "normal" person [242].

Also very important is the economy of cardiac activity, i.e., reduced frequency of cardiac contractions at rest (bradycardia). Prominent modern athletes are known to have pulse rates as low as 40-42 beats/min when at rest, while some have even 36 beats/min. Peter Snell, a student of famous New Zealand coach Arthur Leedyard, and a three-time Olympic champion in running 800 metre and 1,500 metre distances, had a resting pulse of 38; Soviet Olympic champion Peter Bolotnikov, 42; famous Soviet marathon runner Feodosy Vanin, 36; and legendary Finnish runner Paavo Nurmi, 38.

Bradycardia can develop not only in athletes, but in amateur runners as well. Thus, Pilcher [281], studying middle aged subjects, observed, as a result of fitness running, a decrease in resting pulse rate that was proportional to increases in running distances. Increases in weekly effort from 8 to 48 km cause the resting pulse rate to drop from 58 to 45. Males over 40 in our local amateur jogging club have a resting pulse of 48-54, and some even have a resting pulse of 40-42.

The benefits of running for the human body are truly limitless. Many authors report an improvement in liver function that is proportional to the distance run [30]. The reason is a two to three-fold increase in the liver's oxygen consumption, as compared to the resting state—from 50 to 100-150 ml/min [330]. Due to the repetitive vibration of the viscera caused by the striding action of running and an increased secretion of magnesium into the intestines, an improvement in intestinal peristalsis and digestive function is achieved, thus making fitness running an indispensable remedy for constipation.

For a deeper appreciation of the effects of running on the human body, we shall introduce the reader in the next chapter to the basic principles of human exercise physiology.

Chapter Two
THE BASICS OF EXERCISE PHYSIOLOGY

Every vital activity of the human body is provided for through the interaction of two processes: assimilation and dissimilation. Assimilation (anabolism) defines a building function, accumulation, and renewal of substances. Dissimilation (catabolism), on the other hand, is the continuous breakdown of substances and release of energy.

How and where is energy formed, and by what means is it expended? These questions have long occupied our interest.

According to the primitive lore of our ancestors, the energy of life is generated in the heart, and from there, the "internal fire" is disseminated throughout the body via the blood stream. In the middle of the 19th century, the prevailing opinion was that the various activities of the body were carried out because of the energy bound in proteins. But this was only a theory, and not a position based on reliable facts. The scientific data even then indicated convincingly that proteins carried out basically a building function, and that their role in energetics was insignificant.

Right up till the the beginning of the present century, scientists thought that chemical energy was released only in the presence of oxygen, that is, through oxidation reactions. However, it was in the second half of the 19th century that Pasteur challenged that point of view, with his discovery that among microorganisms (bacteria and fungi) the breakdown of some sources of energy proceeds without the participation of oxygen. But this discovery did not make much impression on the proponents of the "oxygen theory" and did not compel them to a new search.

In the middle of the 19th century, Robert Mayer discovered the law of energy conservation. The story of this discovery is worth telling. Mayer, a ship's doctor, was treating the crew of his ship for pneumonia. Upon arriving at the island of Java, he had to take blood from the sailors who had fallen ill. Much to his surprise, he discovered that their venous blood, which is usually darker than the oxygen rich arterial blood, on this occasion showed very little difference in color from arterial blood. This led him to assume that in a hot climate, the body responds with a less intensive exchange of substances. Mayer arrived at the conclusion: "In biological processes, matter and energy cannot be created or destroyed, although they can be changed in form."

As the years passed, new experiments were conducted. Laboratory research was now based primarily on frog neuromuscular preparations. The isolated muscle was induced to contract in various conditions—in the presence of oxygen, in an atmosphere of nitrogen, and in a special oxygen-free solution. The results severely undermined the position of the proponents of the "oxygen theory." Without oxygen, the muscle still contracted, even though somewhat less intensely.

In 1922, the Nobel prize for physiology and medicine was awarded to two prominent scientists, Archibald Hill (English) and Otto Meyerhof (German). They had been successful not only in discovering a new pathway for energy formation, but also in establishing a sound theory, for their time, regarding the body's chemical metabolism. It was established that glycogen breaks down without oxygen, becoming lactic acid. In the process, a significant quantity of energy is released. When this chemical reaction occurs, oxygen is already present. The oxidation of lactic acid is accompanied by the formation of a large quantity of energy.

Later scientific discoveries demonstrated convincingly that this energy exchange is able to occur even without glycolysis, that is, without the breakdown of glycogen. Therefore, there must be other types of "fuel." Soon afterwards, substances were found that proved to be energy rich phosphate compounds, which received the title "macroenergetic."

A little more than 50 years ago, the German scientist K. Loman, doing research on rabbit muscle, discovered an important chemical compound, adenosinetriphosphate (abbreviated ATP). Since the chemical formula for this substance is quite complicated, it would take a quarter of a page to write it. Therefore, we'll settle for a simplified explanation: ATP is made up of adenosine (symbolized with the letter A) and three phosphoric acid residues (P). Therefore, a schematic description of ATP would look thus: A-P-P-P. If ATP loses one phosphate during the breakdown of phosphate groups, then it becomes a different substance—adenosinediphosphate (ADP), and energy is released. However, in order to reunite a phosphate with ADP again, there is an energy demand.

Curiously, the interrelationship between ATP and ADP resembles a "vicious cycle." The greater the concentration of ADP in the cell, the more rapid the synthesis of ATP and tissue respiration. But the level of ADP, in turn, depends on the rate of breakdown of ATP. So it turns out that the augmentation of one process inevitably involves the activity of the other. The self-regulation of a biological system, worked out by nature, permits regulation and control of one of the mechanisms of the energetics of the living body. Taking into account the important and diverse role of ATP, it has been assigned several nicknames: "energy bank," "battery," and others.

Today, energy production is seen in the following way: Cells contain small structures called "mitochondria" (figure 2), which are compared to power plants. Mitochondria contain over 50 different enzymes active in the breakdown and synthesis of various chemical compounds. One cell can contain up to 2,000 mitochondria. The inner and outer surfaces of a mitochondrion are covered with thousands of tiny particles that contain effective biochemical systems responsible for the synthesis of energy-rich substances. It has been calculated that the energy of these particles per unit of muscle weight equals the energy of the engines of a jet plane during take-off, and their efficiency is approximately 80%, which is much higher than the efficiency of many jet engines. Approximately one-half of the energy produced in mitochondria is converted into heat, while the remaining energy is preserved in the form of chemical bonds within the ATP molecules. But, unfortunately, the amount of ATP in a cell is limited and only its constant replenishment will provide normal muscle functioning.

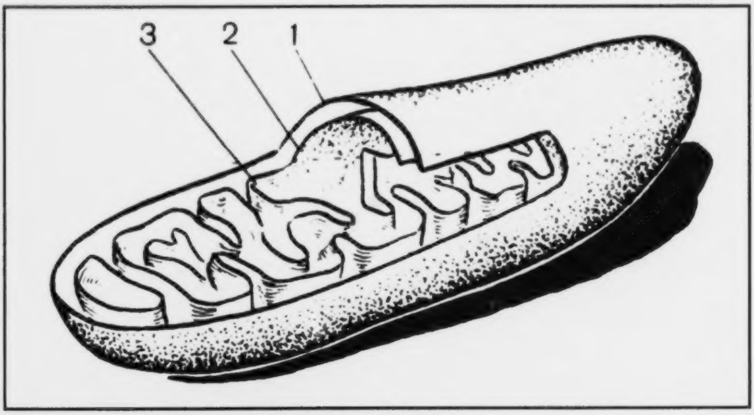


Figure 2. Structure of a mitochondrion:
1- External membrane, 2- Internal membrane, 3- Cristae

And now, let's make another historical digression. In 1930, the Soviet biochemist V. A. Engelhart established that ATP can be resynthesized in red blood cells (erythrocytes). The same process happens in a muscle cell. The breakdown of ATP occurs right along with its resynthesis. The biological significance of this is enormous! If there were no resynthesis of energy sources as they are depleted, the energy source would be quickly exhausted. In this respect, ATP is much like a battery, which is not only discharged but also recharged in the course of operation.

Schematically, the process of energy formation is as follows: ATP is the energy source for muscle contraction. In order for a muscle to contract repeatedly, ATP must not only be spent, but also restored. The energy needed for this is provided by oxidation of "combustible" elements, carbohydrates, fats, and proteins.

There are two ways for ATP restoration: (1) anaerobic, that is *without* oxygen; and (2) aerobic, that is *with* oxygen. One of the anaerobic reactions is breakdown of a special chemical compound, creatine phosphoric acid (CPA), responsible for fast recovery of ATP. However, the amount of CPA is also limited and is quickly depleted as a muscle works. Another anaerobic reaction has greater potential: the breakdown of glycogen.

The discovery of glycogen is connected with the name of the British biochemist, Hans Adolf Krebs, who in 1937 described a cycle of chemical reactions for the oxidation of carbohydrates (the Krebs cycle.) How does this process proceed? First, glucose ($C_6H_{12}O_6$) is split in half on the biochemical conveyer into two molecules of pyruvic acid. Then another conveyer is turned on, where 10 enzymes complete the oxidation of carbohydrates into the final products, carbon dioxide and water (CO_2, and H_2O). This process is slower, but has a longer effect. The energy produced can sustain a few minutes of intensive work.

The second method of ATP recovery, aerobic oxidation of carbohydrates, is the most effective. This type of oxidation enables a muscle to work for several hours. The main energetic reaction, requiring oxygen, takes up where the anaerobic phase leaves off, and completes the total cycle of energetic reactions (figure 3).

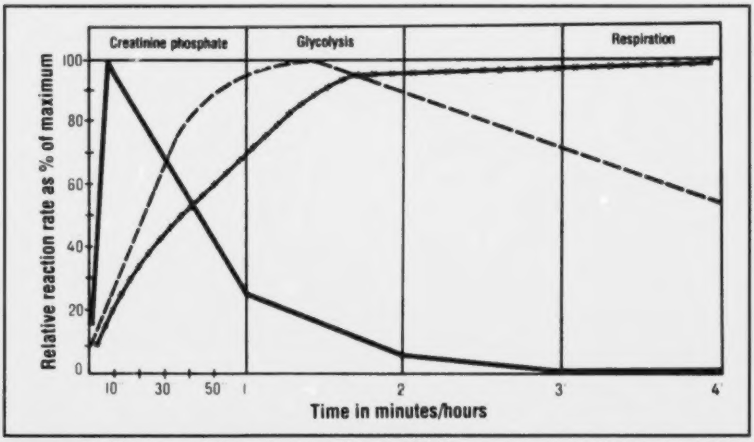


Figure 3. Graph of the cycle of energetic processes during muscle activity (from N.I. Volkov). During the initial seconds, the creatinine phosphate reaction occurs, then glycolysis. Respiration then completes the whole cycle of energetic processes.

Thus, the success of any muscle activity, including running, greatly depends on the body's aerobic capacity—the ability to meet the demand for oxygen.

An important test of aerobic capacity is maximum oxygen consumption. (Scientists throughout the world use the symbol "VO_2" or "VO_2max" for maximum oxygen consumption.) This parameter reflects the effectiveness of the interaction between the respiratory, cardiovascular, and circulatory systems. And it is no accident that elite athletes have demonstrated the highest VO_2 readings — 5.5-6.6 liters (70-85 ml/kg/min). Thus the famous runner P. Bolotnikov had a VO_2 of 83 ml/kg/min.

Let's review some of the components of the test for aerobic performance. Pulmonary respiration is the system that provides for passage of air through the lungs. It is determined by the vital capacity of the lungs, the frequency and depth of respiration—the capacity for maximum ventilation. (See figure 4.)

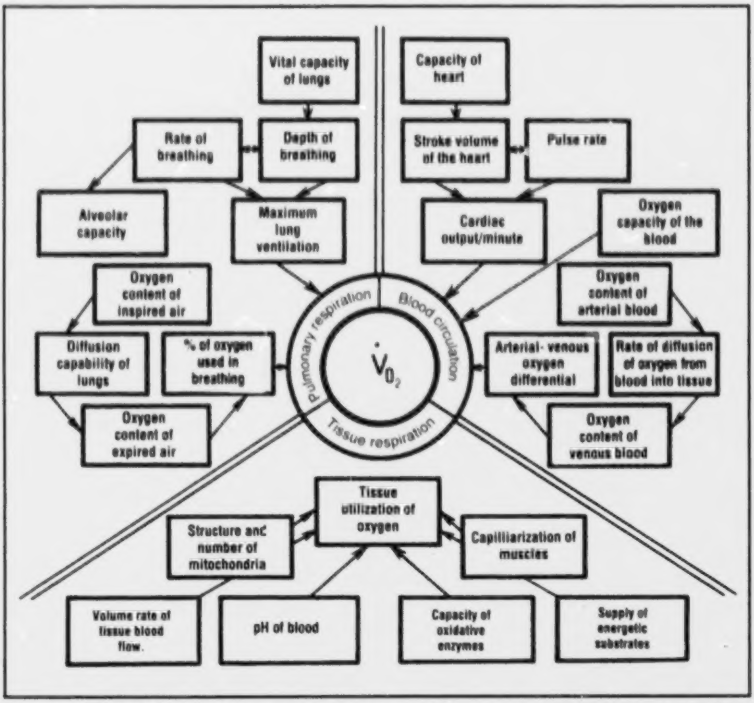

Vital capacity of lungs
Capacity of heart
Rate of breathing
Depth of breathing
Stroke volume of the heart
Pulse rate
Alveolar capacity
Maximum lung ventilation
Cardiac output/minute
Oxygen capacity of the blood
Oxygen content of inspired air
Oxygen content of arterial blood
Pulmonary respiration
Blood circulation
Tissue respiration
$\dot{V}_{O_2}$
Diffusion capability of lungs
% of oxygen used in breathing
Arterial-venous oxygen differential
Rate of diffusion of oxygen from blood into tissue
Oxygen content of expired air
Oxygen content of venous blood
Tissue utilization of oxygen
Structure and number of mitochondria
Capilliarization of muscles
Volume rate of tissue blood flow.
pH of blood
Capacity of oxidative enzymes
Supply of energetic substrates

Figure 4. Basic factors governing maximum oxygen consumption (VO_2).

To provide a high consumption of oxygen during exercise, no less than 180-200 liters of air must pass through the lungs each minute. Otherwise, blood will not be sufficiently saturated with oxygen and muscles will not receive enough oxygen during exercise.

The respiratory and cardiovascular systems are so closely connected that they are often referred to by the name of the cardiorespiratory system. The heart is our indefatigable life-pump and, to a great extent, it limits our maximum oxygen consumption. It is even possible for the lungs to ventilate a large volume of air, while the heart (with limited "traffic capacity") might not allow the body's requirements to pass through.

So it is not surprising that the heart endures stress more often than other organs. Active exercise and sports cause considerable impact on the heart; thus the term "athletic heart" is sometimes used to refer to structural and functional characteristics referring to high performance of that organ.

Soviet scientists V.L. Karpman, S.V. Kruschev, and I.A. Borisova (1978) discovered an interrelationship between the capacity of the heart and the performance of an athlete: The greater the performance and level of training of an athlete, the greater will be the capacity (output) of the heart. For example, middle and long distance runners have a heart capacity of 1,020 cm^3 (14.9—15.2 cm^3/kg).

An increase in the heart's dimensions reflects closely the increase in its reserve capacity. And this, in turn, determines the logical correlation between cardiac output and pulse rate during exercise, and enables the cardiac muscle to pump 35-40 liters of blood per minute. A heart with a lower reserve capacity cannot provide the necessary transport of oxygen.

Aerobic capacity (VO_2) is determined by a number of factors. For now we'll discuss just one of them: supplies of energy substrates, in particular glycogen, which is an important source of energy.

Carbohydrates are "luckier" than oxygen; for nature made it possible to store them—to actually accumulate deposits of sugar. Carbohydrates are found in the form of glycogen (2 grams per 100 grams of muscle tissue) in muscles and in the liver, while the total carbohydrate content of the body is 400-600 grams.

During super long-distance running, the blood sugar level drops approximately in half (figure 5). A considerable decrease in the blood sugar level (50-60 mg%) is accompanied by physical exhaustion.

During prolonged muscular activity, the decrease in blood sugar level is paralleled by its decrease in the liver and in the muscles. But this does not indicate a drain of carbohydrates. Special physiologic mechanisms protect the body's energy resources.

However, under conditions of prolonged work (a marathon, for example) low levels of carbohydrates may limit efficiency. V.S. Farfel has made some interesting observations in this regard. Several athletes ran an experimental superlong run following a carbohydrate free breakfast consisting only of meat and eggs (not even bread). The majority came to the finish line extremely exhausted, while one participant, the ex-champion of the USSR in marathon, had to retire at 19 miles. His blood sugar level dropped to 38 mg%. Farfel hypothesizes that "the intake of sugar is the only method of preventing carbohydrate depletion that occurs in prolonged athletic exertion."

Age and sex also considerably affect the body's aerobic capacity (figure 6). Thus, maximum oxygen consumption is lower for women than it is for men. But in the age range of 10 to 70 years, the change in VO_2 is approximately the

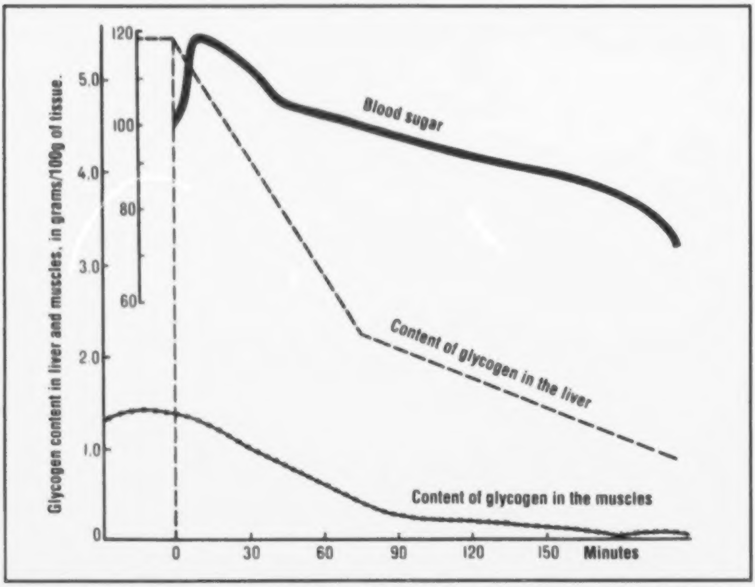


Figure 5. Graph of changes in blood sugar levels and glycogen content in liver and skeletal muscles during prolonged work.

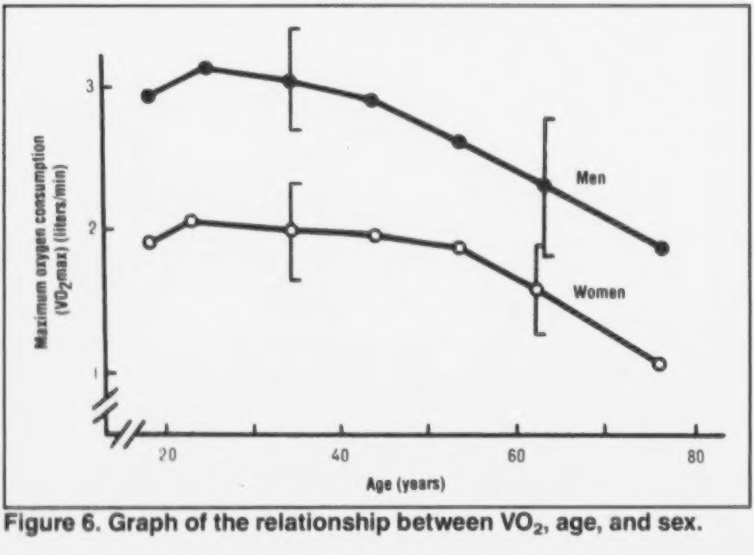


Figure 6. Graph of the relationship between VO_2, age, and sex.

same for both men and women. With age, the level of VO_2 drops. The highest aerobic efficiency has been observed in the 23-30 age range. Accordingly, the majority of record performances have been "turned in" by this age group.

Because of our anaerobic sources of energy we are able to work not only under conditions of sufficient oxygen supply, but also "on credit" as well—that is, with an oxygen deficiency (known as an "oxygen debt") in the tissues.

The body's anaerobic capacity (anaerobic efficiency) depends on a number of factors. (See figure 7.)

During running or other exercise, if an anaerobic reaction occurs, a build-up of lactic acid will occur and an oxygen debt is accrued, the maximum amount of which is a reliable test for anaerobic efficiency. The English physiologist, Hill, was among the first to determine this parameter, which he measured at 18.7 liters. Subsequent studies produced even higher measurements of 20-23 liters. As in the case of VO_2, such high oxygen debts are observed only in highly conditioned athletes. Those not engaged in sports or active fitness exercise will have levels no higher than 4-7 liters or 60-100 ml per kg of body weight [N.I. Volkov].

Aerobic reactions provide for most of the energy in long distance running, but anaerobic processes too have an important function. For example, transition from the state of rest to running always creates an increased demand for oxygen. But the organs of oxygen supply are "slow to respond." They are not readily "brought to bear" on work with maximum intensity. This is where our capacity to work in oxygen deficiency comes to the rescue, for only a limited reserve of oxygen can be accumulated in the body: only 400-500 ml in the lungs, 900-1,000 ml in the blood, and 300-400 ml in muscles and tissue fluids. (See figure 8.) Unfortunately, this amount is drained in a few seconds of running.

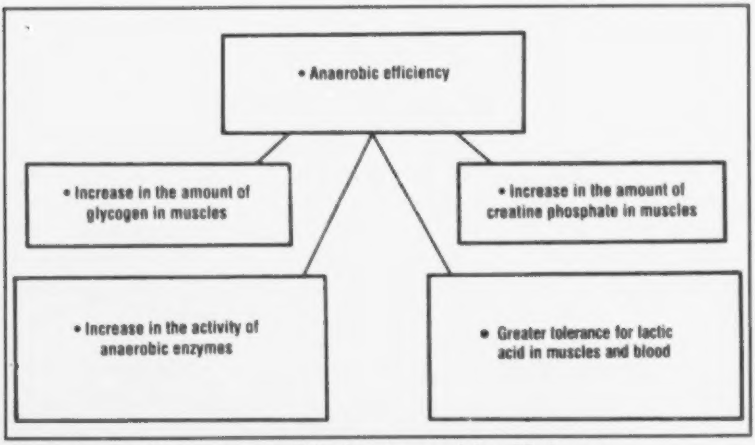

• Anaerobic efficiency
• Increase in the amount of glycogen in muscles
• Increase in the amount of creatine phosphate in muscles
• Increase in the activity of anaerobic enzymes
• Greater tolerance for lactic acid in muscles and blood

Figure 7. Factors responsible for anaerobic efficiency.

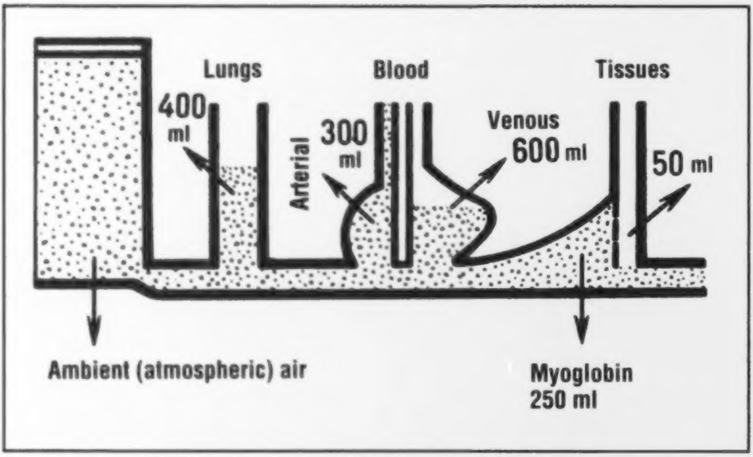


Figure 8. Reserves of oxygen within the human body.

Muscles contain a special albuminous substance called myoglobin that serves as a sort of "oxygen container." Myoglobin is important for transporting oxygen from blood into muscle fibers. It is a proven fact that animals that are able to function for a long time without oxygen have a higher content of myoglobin in their muscles.

A.B. Handelsman, studying the process of blood oxygen saturation in long distance runners, discovered that athletes who train for endurance have an exceptional capacity to overcome significant hypoxemia (reduced blood oxygen) and hypercapnia (elevated blood carbon dioxide.)

How can the higher aerobic and anaerobic efficiency of athletes and fitness exercisers be explained? First of all, it is due to their physical activity and systematic training. Recently there have been indications that maximum oxygen consumption is determined genetically to a great degree (table 8) but, even so, such potential becomes effective only through dedicated training.

Authors	Index of heritability %
Schwartz	79
Jedda et al.	66
Zatsiorsky & Sergienko	73

Table 8. Data regarding aerobic efficiency in twins.

Much scientific data attest to the positive effect of training. Most importantly, training improves the body's ability to adapt to various muscular work loads. This adaptation is possible due to increased energy resources, significant changes in several systems, improved physiologic efficiency, acceleration of functions during the early stages of work, increased stability of the body's internal environment, and improvement of recovery processes.

In 1927 it was first established that physical exercise increases the level of glycogen (an important fuel for energy) in muscles. Great accumulation of this carbohydrate in trained muscles makes them independent of the sugar supply that is transported in blood. N.N. Yakovlev has conclusively demonstrated in tests with animals that the level of glycogen is also increased in the liver. (In trained animals, this level is 50% higher than in untrained ones.)

	NON-ATHLETES	FIRST RATE ATHLETES	NATIONAL/WORLD-CLASS ATHLETES
Content of glycogen in muscles in grams per 100 g of muscle	1.46 (1.08–1.95)	1.8 (1.23–2.92)	2.2 (1.77–2.81)

Table 9. Levels of glycogen in working muscles: After Hermansen, 1977 [184,A].

Studies of glycogen content in different muscles have shown that during endurance exercise, the level of glycogen increases only in working muscles (table 9). For runners, for example, these would be the quadriceps femoris and gastrocnemius. Muscles that are are not substantially exerted undergo no substantial change.

Glycogen levels can be increased with the aid of a special carbohydrate diet. When fat products predominate in the diet, glycogen levels are at 0.6 per 100 gram of muscle. In a mixed diet, the level is found to be 3.0 grams; while a level of 4.7 grams can be achieved with a carbohydrate diet. This difference can cause a great increase in the duration of work possible at 75% of VO_2max (until exhaustion occurs).

However, "carbohydrate loading" is advantageous only when one's effort approximates the point of exhaustion, for example, a run of 18-22 miles. The content of muscular glycogen cannot be increased by diet alone, without exercise. In the case of high carbohydrate intake without exercise, the surplus of carbohydrates will be converted into fats and stored as fat deposits.

Training also affects the cardiac output per minute, as the heart develops the capacity to pump a larger amount of blood each minute. Thus, for athletes, the cardiac output per minute reaches 35-42 liters; while for untrained persons, this figure is 25-30 liters. The improved reserve capacity of the heart is due mainly to an increase in the stroke volume.

The well-known German physiologist, Reindell, studied the heart performance of a middle-distance runner for six months. Over this period, the stroke volume of the heart increased to 220 cubic cm. Then, for six weeks, the runner did not exercise and his stroke volume fell to 130 cubic cm. Regular exer-

45

cise and fitness training affect the volume of the thorax, the vital capacity of the lungs, the capacity of both inhalation and exhalation, and the general ability of the body to meet the demand for oxygen.

Trained persons have a maximum lung ventilation (volume of air that passes through the lung per minute) that reaches 170-250 liters per minute, while untrained persons never achieve such great ventilatory capacity.

Scientific studies have shown an increase in maximum oxygen consumption during training. This increase is closely related to the increase in the stroke volume of the heart (table 10).

CATEGORY OF SUBJECTS	STROKE VOLUME CUBIC CM	VO_2max ML./MIN
Trained	962	4456
Untrained	735	2800

Table 10. Heart capacity (stroke volume) and VO_2 max for trained and untrained males

But does VO_2 always increase? The figures show that often there is no direct relationship between an improvement in sports performance and maximum oxygen consumption (VO_2max). The point is not just to possess a high capacity for energy, but also to know how to use it efficiently. To conserve the body's energy resources is primarily a matter of perfecting technique. To this end, a biomechanical approach is used for developing economically efficient variations in athletic technique, or, alternatively, athletes are advised to adopt relaxed and unrestrained movements.

Muscular relaxation causes an inhibitory process within nerve cells. During this process, the metabolism of "recovery" is activated in the nerve cells.

How do we determine the level of economy or efficiency when performing various movements? One of the ways is to assess the energy value of each movement separately. The more mastered is the technique of a movement, the more efficient will be its energy consumption.

Each sport has its own degree of efficiency. For example, an accomplished skier uses 18-20% less energy for a given amount of work than a less accomplished athlete. For a bicycle racer, this difference may be up to 11.7%; and for a runner, not more than 7%.

Special exercises that involve alternating muscular effort are used to develop the ability for muscular relaxation. Athletes are advised to contract and relax muscles at will or, choosing a pause, to momentarily "drop" the muscular tension. Also effective are exercises of the "break" type, wherein intense efforts are rapidly alternated with relaxation such as jumping or throwing a ball or other small object.

The following methods are occasionally used in sports for dealing with excessive muscular tension: switching attention to a different subject, recalling a happy event, counting, discussing an unrelated subject, concentrating on inhaling and exhaling, or closing the eyes briefly, for example, during a running exercise. Positive emotions, smiling or laughing, are prerequisites for high efficiency, lightness, and freedom of movement. N. N. Yakovlev in Leningrad measured the blood sugar levels in athletes during exciting and boring training sessions. The body "voted" for the emotional sessions as the blood sugar levels increased during these sessions.

Athletes are also able to use the force of "inertia" successfully by "leaving the competition" for a short period of time to relax and rest. In running, this method is called "free motion" and is characterized by lessening the tension of the muscles that do most of the work. The runner runs for a few feet by force of inertia, without reducing speed, and then resumes normal running technique. According to the data of V. V. Mikhailov and V. F. Popov (1973), during "free motion," the electrical activity of the leg muscles drops only in this "coasting phase" while the duration of relaxation periods is virtually unchanged. People engaged in fitness running should learn the practice of inertia, using "micro-intermission" for brief periods of relaxation and rest.

Another method for improving efficiency is "perfecting" the body's functions. The aerobic mechanism of energy formation is more advantageous than the anaerobic one, so increasing the number of aerobic processes will provide a more efficient mode of energy supply. For this reason, the increase in maximum oxygen consumption which results from training, together with the ability to maintain a high level of oxygen consumption at all stages of work, will result in more economic energy formation. The maximum possible level of oxygen consumption is limited primarily by the cardiovascular system. The better the heart is able to supply blood to working muscles, the more effective will be ATP recovery.

Not long ago scientists debated the question of optimum distribution of effort for running. Experience has proven that the greatest efficiency is provided when work is distributed evenly. ("Varying work" with speed fluctuations over 3-5% is less efficient.) The physiologic implications of this are clear: "Varying work" is accompanied by acceleration and slowing down, with anaerobic processes predominating. Evenly distributed work, on the other hand, provides better conditions for meeting the demand for oxygen during running exercises.

The level of training or fitness also enters into the formula of this discussion. In fact, the level of fitness which the body brings to a given task will greatly affect our ability to handle the stresses which accompany the initial stages of work.

The body is "slow to start" (full of inertia). The reason for this is in the inertia of nerve cells that cannot adapt promptly to a higher level of physiologic activity. Every movement, regardless of how complex, requires a series of nerve reactions in the cerebral cortex. In short, a whole "ensemble" of stimulation and inhibition processes needs to be tuned up. To make this "ensemble" play, all its instruments should be tuned to one physiological rhythm. The time this takes is known as the period of "work entry."

Training, especially in the early stages, accelerates this entry process and assists us in reaching our functional ceiling. As a result of training, muscles are conditioned for "quicker readiness," breathing and circulation become more active, and the demand for oxygen can be met mainly through aerobic processes.

Warm up is an important means of accelerating the entry into work. A combination of physical exercises performed prior to the main activity enables us to overcome our body's "inertia" and prepare it for work.

People who are active in fitness exercise and sports have an ability to cope with considerable changes in the body's inner environment. Also, regular physical stress increases the capacity of our recovery processes.

Strictly speaking, after a training session, it is not actually a "recovery" which occurs, but rather a transition to a new state, different from the initial one; otherwise how could the increase in our level of fitness be explained?

Often, when recovery is discussed, the reference is only to the processes following the exercise. But recovery processes are already activated during the course of the work, while L.A. Ioffe even speaks of preworking recovery.

The body's capacity to recover is very specific. So much so that in sports medicine and sports physiology, the study of the recovery period is the best test for assessing the fitness level of an athlete or patient (figure 9).

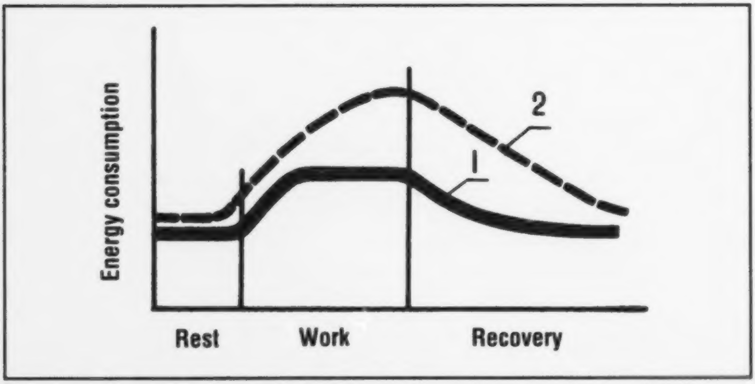


Figure 9. Graph of energy consumption by trained (1) and untrained (2) persons performing identical work.

The common laws of energetics of muscle activity serve as a sort of foundation for understanding the energetics of running. Let's turn to some mathematical formulas and figures.

Energy consumption depends on speed and body weight and can be expressed by the formula: E = [(18.0 x V) − 20] x W, where E = energy consumption (in kcal/kg/min), V = the speed of running (in km/hr), and W = body weight in kilograms [89].

Let us calculate the energy consumption for a person who weighs 70 kg, running at 10 km./hour:

E = [(18.0 x 10) − 20] x 70 = 11200 cal/min. = 11.2 kcal/minute.

Accordingly, this person's energy consumption for one hour will be 672 kilocalories (11.2 x 60).

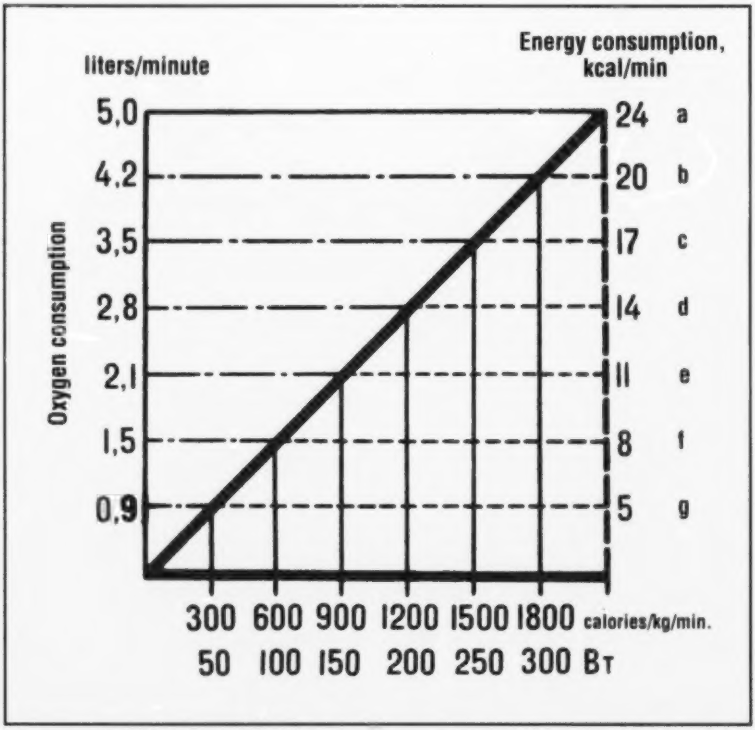


Figure 10. Relationships between oxygen and energy consumption and speed of running (a = 20 km/hr, b = 16 km/hr, c = 13 km/hr, d = 11 km/hr, e = 9 km/hr), and walking (f = 7 km/hr, g = 5 km/hr).

The relationship between energy consumption and speed of running and walking can be calculated with the graph shown in figure 10. For an approximate calculation of energy consumption while running at an aerobic pace. Margaria [239] has proposed the following figures: 1 kcal for 1 kg of body weight per 1 km of distance. Accordingly, a runner weighing 70 kg burns 700 kcal if he/she covers a 10 km distance.

Similar calculations can be done for walking using the formula: E = (0.007 x V^2) + 21 where V is expressed in meters/min. For example, if a person walks at 6 km/hr, 100 meters is covered each minute. Then E = (0.007 x 100^2) + 21 = 91 kcal/kg/min. For a person with a body weight of 70 kg, energy consumption will be 6,370 cal/min (6.37 kcal/min) or 380 kcal/hour (6.37 x 60).

Remember, however, that these calculations do not take into account such factors as terrain and running surface (asphalt, unpaved road, grass, etc.). To illustrate the effect of such factors, a male weighing 70 kg walking on a level surface at a speed of 5 km/hour burns 4 kcal/minute, while going uphill on a 5° slope his calorie consumption will almost double—to 7.8 kcal/minute, while going downhill (at 10°) the consumption of energy drops to only 1.8 kcal/min.

And also on the subject of energy consumption, remember that there is a big difference between fitness running and sports (high performance) running. For example, an athlete running at 15 km/hour performs work at the rate of 1,800 kgm/minute and consumes 4 liters of oxygen per minute (which burns 20 kcal/minute). By contrast, a fitness runner (jogger) with an average speed of 10-11 km/hour performs work at only about half this rate: about 1,000 kgm/minute with an oxygen consumption of about 2.2 liters/minute, burning about 11 kcal per minute.

In addition to mathematical formulas, various graphs are used for determining energy consumption.

Which is easier—to run slowly or to walk fast? To answer this question we must discuss the term "energetic optimum." In rhythmic activities (running, walking, biking, swimming, etc.) this term designates the speed at which energy consumption is minimal. During natural walking or fitness running, a person normally chooses the speed that is near the optimum. In walking, the energetic optimum has been found to be at speeds of 4-6 km/hour (3-4 miles/hr), while for running, the energetic optimum speed is 10-15 km/hour (6-8 miles/hr). (The energetic optimum for riding a bicycle is related to the rate of rotating the pedals and is about 60-70 revolutions per minute.)

The relationship between energy consumption and speed of walking or running is nonlinear (figure 11). Energy consumption for walking at 6 km/hour is lower than for running, but walking at 7 km/hour consumes approximately the same amount of energy as running; while walking at a higher speed will consume more energy than running. As the graph shows, energy consumption is 20 kcal/minute when walking at 10 km/hour; while running at the same speed will require only 11 kcal/minute, or about half as much. (Consuming 1 liter of oxygen is roughly equivalent to burning 5 kcal.)

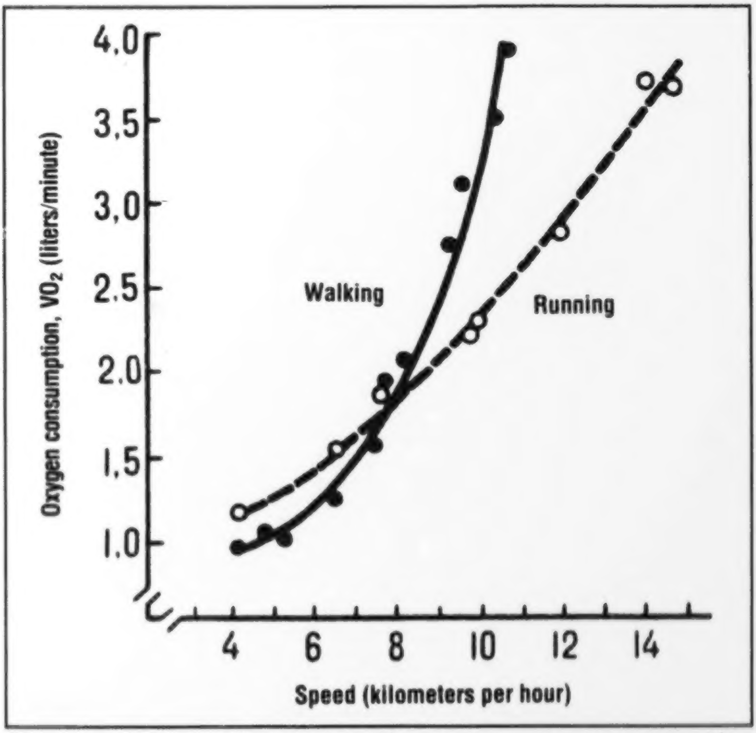


Figure 11. Graph of the relationship between energy consumption and the speed of walking or running; at less than 8 km/hour it is more efficient to walk while running is more efficient at speeds over 8 km/hr.

V.S. Farfel, continuing the research of Hill, proposed the following classification for rhythmic exercises according to levels of exertion: Level 1 = "maximal" exertion (duration of work not more than 20-30 seconds); Level 2 = "submaximal" exertion (30 seconds-5 minutes); Level 3 = "high exertion" (5-30 minutes); and Level 4 = "moderate exertion" (over 30 minutes).

Fitness running is placed in the "moderate" category or Level 4, and we will now look at the physiological changes which occur during exercise at this level of exertion.

1. As a result of improved biological efficiency, there is a marked drop in the resting heart rate (bradycardia); and the heart develops the capacity to sustain a 5 or 6 fold rate increase (above the resting pulse rate) when put to work. (Beginners should count on only a 3 fold rise.) This improvement is the result of the heart's tremendous potential to benefit from exercise.

2. Moderate changes in respiration and circulation are observed at the time of running. But in spite of the long duration and tiring nature of endurance work, functional changes never reach maximum level. A "steady state" is reached and maintained where oxygen demand is met during the exercise, and thus oxygen deficiency is not a problem. Aerobic processes predominate during running, while anaerobic sources of energy scarcely come into play.

3. It is not so much their demonstrated high VO_2 levels (maximum oxygen consumption) that sets experienced runners apart, but rather their more efficient use of oxygen over the distance. For example, the strongest marathon runners can maintain oxygen consumption at 75-90% of VO_2max for a long time due to the large oxygen capacity of their bodies.

4. The energy value of our carbohydrate reserve is 1600-2000 kcal. This amount is not enough for exercise lasting over 60-90 minutes. During prolonged running, the blood sugar level drops from resting levels of 80-100 mg% to 50-60 mg%. If the level drops even lower, total exhaustion occurs. The carbohydrate reserves in the liver are also drained and, as a result, muscles do not get enough glycogen, which is their main source of energy. All this causes a loss of speed, weakened muscles, and dizziness. Everything goes dark before the runner's eyes.

To avoid carbohydrate exhaustion, runners are advised to take sugar while running. Fats are also helpful, and the longer the distance, the greater their role in energy supply. Thus, when the duration of a run is 30 minutes, 60 minutes, and 2-3 hours, the role of fats in energy supply is 10%, 20%, and 50% respectively. As a runner becomes more trained, capacity for earlier fat oxidation increases. As a result, muscular glycogen can be reserved for later use.

5. During prolonged intensive running, weight loss caused by perspiration may sometimes reach 6 pounds or more. Perspiration causes the body to lose salt, and this salt loss disturbs the water-salt balance. (Perspiration contains up to 0.5% sodium chloride.) Since cells can function only with a certain water-salt balance, an increased salt intake is recommended on days of intense training or competition.

Let's look at the important morphological characteristics of the runner's muscles. Already in 1873 the French scientist Ranvier had discovered that the fiber composition in muscles is not uniform. Later, muscle fibers were classified into three groups according to their specific physiologic features: (1) slow, (2) fast oxidation-glycolytic, and (3) fast glycolytic. In different muscles, the ratio of these fibers is not the same; and it is this ratio that determines the so-called "functional profile" of muscles, their strength, speed, and endurance.

Let's look, for example, at the muscles composed mainly of slow fibers—the number of which determines the level of the muscle's natural capacity for endurance (table 11).

MUSCLE	%
Biceps	49
Erector Spinae	56
Gastrocnemius	58
Soleus	84

Table 11. Number of slow fibers in muscles (in %).

Slow muscle fibers contain more mitochondria and more myoglobin. They are also permeated with a network of capillaries and consequently are better supplied with oxygen. Also, they have more highly active oxidizing enzymes, so everything is "set up" for efficient prolonged work, such as running.

Chapter Three
FUNDAMENTALS OF TRAINING

PRINCIPLES OF TRAINING

The Soviet physiologist, Academician L.A. Orbeli once remarked that the essential impact of physical exercise is in "training our trainability." This unusual pronouncement has a deep meaning, however, for the human body has an inherent capacity for adopting new forms of motor activity. This is what training as an organized process is aimed at: to transform the body to a new level of physical fitness.

Experts see fitness training as a combination of several disciplines: physical, technical/tactical, moral (spiritual), and will-power. In our discussion of fitness running, we will emphasize the physical aspects of training. According to prevailing theory, training involves a number of principles: repetition, incremental improvement, and individualization.*

THE PRINCIPLE OF REPETITION

The physiologic basis for the principle of repetition is the study of recovery processes in tissues and in the central nervous system. I.M. Sechenov recognized the enormous impact of recovery processes in the body's development. In his "Reflexes of the Brain" he wrote: "Were it not for the existence of this force, every sensation would be experienced as new—without leaving a trace—even at its millionth repetition." Academician A. A. Ukhtomsky compared a single nervous impulse with a comet, the tail of which is the cause of a number of recovery processes that are the system's response to various stimuli, including physical exercise.

In sports, recovery processes are considered the processes of rehabilitation. I. P. Pavlov had already noted in 1890 that restoration of consumed resources does not stop at the original level, but a certain overcompensation is achieved. He referred to this as "redundant compensation."

Rest following work is an important part of training. If work is repeated without full rest, when our working capacity is still limited, it only results in fatigue. Yet sufficient rest to the point of redundant compensation will yield the optimum training effect.

---

*The German scientist Harre (1971), along with specific principles of training, considers general educational principles: consciousness, clarity, accessibility, etc.

Athletes are usually advised to exercise when not fully rested, so as to develop a capacity for coping with fatigue. Fitness runners, however, will not benefit by such a strenuous protocol. Since exercise is frequently accompanied by intensive mental activity and emotional stress, full rest is essential.

The principle of repetition demands a systematic approach to exercising. Physical exertion should be strictly measured in duration, intensity, and amount; and it should be appropriate for the general condition of each participant. In short, both the character and the sequence of the repetitions must be appropriate.

"Run every other day" is one of the rules for people of middle and advanced age. Daily exercise is undesirable, especially for people over 40, since it can cause excessive fatigue due to limited restorative capacity. In East Germany, for instance, the majority of joggers run 3-4 times a week, and only a few run daily. Experienced runners can advance to 5 days a week provided their medical examination is normal.

Jogging twice a week, on the other hand, is much less effective, while occasional random exercise can even do harm. "A healthy regimen, not an excessive one, will strengthen the body," is the teaching of two renowned sports medicine specialists, Deuser [138] and Dembo [25].

THE PRINCIPLE OF INCREMENTAL IMPROVEMENT*

The principle of incremental improvement provides for the body's adjustment to an increasing training effort. This does not mean that there must be a steady numerical increase, e.g., 20 minutes the first day, 25 minutes the second day, 30 minutes the third day, etc. It is possible to increase the workout considerably, or to maintain the same level, or even to reduce it at times; but a gradual increase is the desired objective. Premature excessive workouts are harmful.

THE PRINCIPLE OF INDIVIDUALIZATION

The workout regimen should correspond to the functional capacity of the runner. It will not be same for all runners, and depends on age, health status, job situation, locale, and lifestyle. Each person must find his or her optimum workout pattern that best matches his or her circumstances and physical abilities. One should never try to match another person's performance.

Before beginning an exercise program, it is necessary to assess your abilities, to consult a physician or a coach, and only then to select an appropriate workout schedule. "Better too little than too much" is a golden rule in running.

---

*Translator's note: The translation is difficult here, but when taken in total context, the authors want to emphasize "gradualness" and also patience—that conditioning takes time and that "haste makes waste."

And another piece of advice for beginners—run alone! When running in a group, tension frequently develops, or a deliberate attempt to keep pace. But differences in physical condition, prior training, sex, or age may prevent this. Thus Gilmore, a well-known journalist and running promoter from New Zealand, who was much in favor of team running in his first book, later abandoned this idea. However, this advice should not be taken too far; for there are some people who need to have a partner. It should be noted that with more extensive training, the advisability of running in a group increases; but even then, it is essential to choose compatible partners.

This principle also calls for individual adjustment of the workout schedule. Thus taking the pulse during exercise provides an adequate measure of ongoing changes and makes it possible to modify the training schedule.

WAYS AND MEANS FOR TRAINING

The main difference between fitness running and sports (high performance) running is the speed. For fitness running, the experts recommend a speed between 4 and 7 miles per hour. Why this particular speed range? Running at a slower speed requires more energy than walking and for this reason is wasteful and fatiguing. Yet running faster than 4-7 miles per hour puts excessive stress on the circulatory system, which is undesirable for people over 40.

Beginners have a tendency to run too fast and should try to limit themselves to about 7 miles per hour, in other words, no faster than 9 minute miles. If you are running faster than 9 minute miles, you are running beyond the boundaries of health or fitness benefits.

Since fitness running is mainly intended to develop endurance, we shall take a closer look at its two principle methods: "interval" and "continuous."*

German trainer and sports physician D. E. van Aacken [80], a prominent expert on fitness running, teaches that the continuous method is more effective and has a number of advantages over the interval method. It results not only in an increase in maximum oxygen consumption but also in a longer period of maintaining it. Furthermore, it does not require the maximal effort, which may present a risk to middle aged and elderly people.

---

*The theory of sports training distinguishes a number of techniques to develop endurance: repetitious and interrupted, continuous (both steady and alternating), combined, and controlled. We will limit this discussion to the interval and the continuous, which are most appropriate for fitness running.

It should also be noted that in the course of interval training, the maximum oxygen consumption (VO_2) increases mainly due to an increase in the size of the heart, which is undesirable for middle aged people. It is much safer and more physiologic to increase aerobic capacity by means of a greater contractility of the heart muscle (stronger pumping force), as occurs typically with the continuous method [25], which is fundamental for developing endurance. The continuous method can have two variations—steady and alternating.

In the alternating mode, when running long distances, the speed changes constantly, causing significant fluctuations in the pulse rate. This can be achieved by cross country running, by "playing" with different speeds, or by running with varying speed on a stadium track—or by combining running and walking. As a rule, it is this alternating technique that is used in the training of athletes.

For the fitness runner, however, it is best to use the steady mode, where the entire distance is covered at a constant pace (light steady running for a period of 30 minutes to 2 hours). Experienced runners may accelerate some toward the end. This is the most economical method with respect to energy consumption.

Steady running for 20-30 minutes is the standard workout for beginners. More experienced runners follow this protocol on their off days to replenish themselves.

For developing and maintaining their endurance level, well-trained runners will normally bring themselves once a week to a long steady run of 1-2 hours along a level course at a pulse rate of 132-144.

During fitness running, the steady mode can be combined with the alternating one. For example:

1. Cross country with slight elevations for 30-90 minutes at a pulse of 144-156 once a week for developing general endurance. This practice is only for thoroughly trained runners under 50 with many years of experience.

2. Alternating short stretches of walking and running ("walk-run") for 1-2 miles at a pulse of 120-132. This is the recommended introductory protocol for beginners during the first few weeks or months of training.

It should be noted that for untrained runners in their middle or advanced years, continuous running presents quite an intense stress that may result in disturbed functioning of the cardiorespiratory system. For this reason, it is critical to alternate running with walking; for example, in the early stages, 60 feet of running alternating with 60 feet of walking. There are also other protocols in which the duration of these intervals is measured according to the time elapsed [106, 220]: at first, one minute of running is alternated with 3 minutes of walking, etc. (see figure 12).

However, designing schedules with rigid timing is not very practical, since it ignores the first principle of training—individualization of the workout.

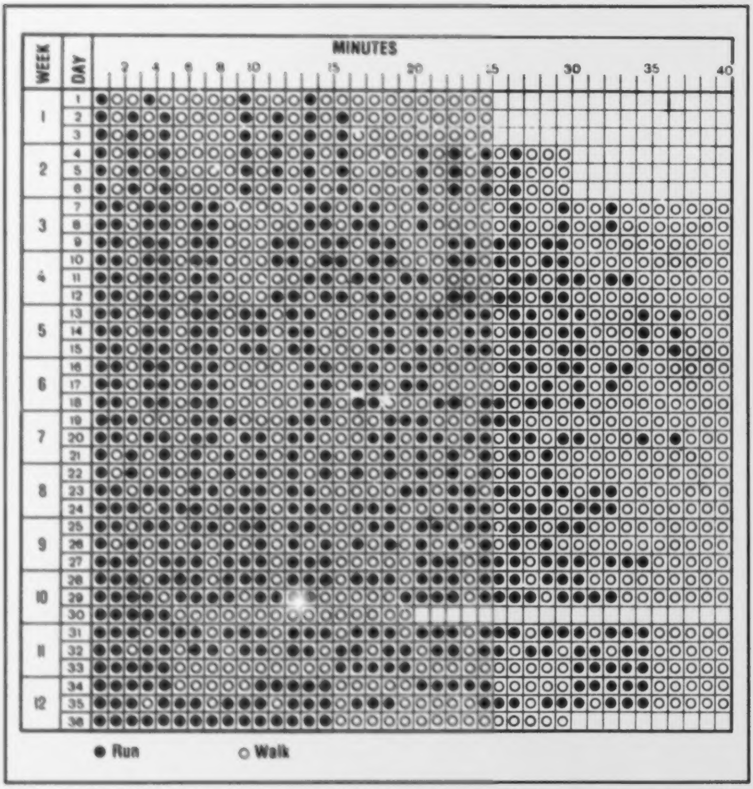


Figure 12. Training scheme of alternating walking and running for beginners.

The intervals of running and walking cannot be the same for everyone. They should actually be determined individually so that the pulse rate does not exceed the optimal level. When this happens, the intervals of walking are increased until the pulse rate returns to optimal. Increasing the running intervals and shortening the walking intervals is done gradually over the course of training.

TRAINING LOAD AND INTENSITY

The key question in the methodology of fitness running is the selection of "optimal training load." * This is determined for all rhythmic exercises by the following factors:

- Duration of the exercise (the distance covered)
- Intensity of the exercise (speed)
- Duration of the rest periods between exercises
- Character of the rest (whether engaging in other activities—"active" or "passive" rest)
- Number of repetitions for each exercise
- Coordinative complexity of the exercises

Changing these factors and their combinations will increase or reduce the training load and, as a result, influence the body's responses.

The "workout load" in fitness running is normally determined by the distance and intensity. For the best fitness results, this "load" should be optimal and requires taking three factors into account.

1. The load should be tailored to each individual's needs.

2. It should be tailored to daily energy consumption; i.e., there should be compensation for energy shortages.

3. It should stimulate an increase in fitness and a reduction in the risk of coronary heart disease.

1. INDIVIDUALIZATION OF THE WORKOUT

The optimum workout load for a fitness runner means the minimal weekly mileage that will yield the best improvement in his/her overall physical condition at any given stage of fitness. Naturally, the optimum workout will increase gradually as physical conditioning improves. Increasing the workout too aggressively may cause overstraining of the cardiovascular system and aggravation of various chronic diseases in middle aged and elderly people. Thus, beginners should follow a workout protocol that will make them feel good, yet still provide the available health benefits. Beginners may be advised

---

*Translator's note: The Russian and English languages are not "symmetrical" here. The Russian word "nagrushka" can mean burden, load, stress, etc. The meaning becomes clearer as one reads on, but is best understood by reference to the formula popularized by Ken Cooper, "FIT," which stands for Frequency, Intensity, and Time. It is the "product" of these three factors that we westerners are now trained to think of as our training nagrushka.

to alternate intervals of running and walking for distances of 1-1.5 miles 2 or 3 times a week.

2. COMPENSATION FOR ENERGY SHORTAGES

It is a well known fact that people engaged in physical labor who exert large amounts of energy suffer from numerous health problems and heart disease only half as often as people occupied in sedentary professions that require only mental activity and much lower energy consumption. While young men performing hard physical labor burn 3,500 kcalories as a daily average, this same figure for clerks does not exceed 2,800 kcalories [148]. The difference in energy consumption is provided by running at moderate speed (6 miles/hr) for one hour. In view of these facts, the optimum weekly running workout for 30-35 year old males may reach 31 miles (3,500 kcal) over 5 workouts. Since metabolic activity as well as energy consumption are reduced with age, workout protocols should be adjusted accordingly. Paffenberger [274] maintains that the optimum level of energy consumption during physical exercise for middle aged individuals should be about 2,500-3,000 kcal weekly (19-25 miles at a slow pace).

The daily energy consumption for women is somewhat lower, at 2,200 kcal a week for housewives, and 2,800 kcal for agricultural workers. The difference is 600 kcal a day [273] or 3,000 kcal each week. Accordingly, the upper limit of the workout for women will be slightly lower.

3. INCREASING FITNESS AND REDUCING THE RISK OF CORONARY HEART DISEASE

A number of studies dealing with endurance indicate that optimum body functioning will result from continuous rhythmic workouts of moderate intensity over a period of at least 30 minutes [19, 29, 65, et al.]. Cooper has determined that the minimal workout load required for improving conditioning for males consists of 10 miles of slow running each week—or three workouts of 30 minutes each — which in Cooper's "point system" will earn 30 points. For women, this minimum is found to be 7.5 miles a week, or 24 points. This training regimen maintained over several months resulted in an increase in maximum oxygen consumption up to 42 ml/min/kg for men, and 35 ml/min/kg for women. According to Cooper, these results point out the correct "dose" of exercise necessary for health. Running two miles over 20 minutes three times a week is the most popular protocol among beginners at the Health Center in Dallas. In Japan [143], a 14% increase in maximum oxygen consumption has been observed after maintaining a similar training regimen for 12 weeks.

In the United States and Canada, the most common exercise regimen is 3 times a week for 20-30 minutes [143]. A similar workout schedule is believed to be optimal also in the East German Republic [220].

French scientists Leon and Bloor [233], following ten weeks of forced training of animals on a treadmill for 30 minutes three times a week, have observed a significant increase in capillary blood flow in the heart muscle as well as improved coronary blood flow. They also noticed that these changes were not present after a protocol of 15 minute workouts. Thus it is apparent that a workout regimen of 30 minutes three times a week is minimal for fitness running.

This is also supported by the fact that similar protocols significantly reduce the risk factors for coronary artery disease. Thus Penny [278] demonstrated a clear reduction in blood pressure in healthy middle aged persons. Wood et al. [343] documented a normalization of all facets of lipid metabolism—as well as weight loss and reduced body fat content—following a workout protocol of 18 miles per week.

Berthezene [101] has demonstrated normalization of lipid metabolism even following a protocol of only 8 miles per week. The data of other studies also indicate that often it is the intensity or quality of the workout rather than its mileage or duration that makes a difference [153]. Thus Dressendorfer and Gahagen [145] observed no difference in the levels of cholesterol, triglycerides, and low density lipoproteins between runners doing 8.5 miles a week and those who run 36 miles a week. Yet for the sake of objectivity, we must acknowledge that some studies have recorded direct proportionality between the changes in lipid metabolism and the duration of the workout load [177, 231, 313].

As for the maximum allowed amount of exercise, there is no consensus. When the weekly mileage is increased beyond 40 miles, it is accompanied by an increase in injuries to the musculo-skeletal system, as well as a risk of excessive strain on the cardiovascular system [Cooper, 122]. An additional risk is that of "positive addiction," which is most likely to develop when the weekly mileage exceeds 56 miles. Apparently this is caused by excessive stimulation of the endocrine hormone system resulting in an overabundance of the hormones which normally moderate and control our mood but, in a high-dose running situation, create a sense of euphoria. A passion for running, of course, need not be considered a bad habit. Yet even people who are in good health should stay within the reasonable limits set for working out.

When weekly mileage gets beyond 30-50 miles, young women sometimes experience menstrual irregularities as a result of reduced body weight and body fat composition [107], a situation that may cause sexual disorders. Tuchman and Gondola [324] report an improved psychological state and general mood as well as a reduction in tension in women who run 12-25 miles per week. When this distance was increased to 50 miles per week, these parameters (mood and tension) were significantly reduced. The authors conclude that, in moderate amounts, running improves psychological well-being.

The negative impact of excessive exercise upon immunity must not be ignored. Shubik and Levin [77] and Levando [41] observed a reduction in general immune defenses and immune responses when athletes reach the peak of their training schedules.

Reduced immunity can also be the result of a workout schedule that exceeds the optimum. Thus one of the authors of the present study, while inappropriately increasing his workout load, and being under chronic physical stress, continually had flu symptoms. However, when the training regimen is moderate and adjusted to fit the body's condition, it contributes to improved immunity and resistance to numerous diseases [40,149, 197]. Thus, Korobkov (1980) reports an increased resistance to oxygen deficiency, to toxic substances, to penetrating radiation, and to exposure to temperature extremes (both high and low) as a result of moderate physical exercise.

For advanced runners over 40 who have not previously engaged in sports, the optimum workout is 19 miles per week for men and 17 miles for women, which corresponds to an energy consumption of 2,200 kcal. According to the American Medical Association data, the optimum running workout for people over 40 may fluctuate from 30 to 60 minutes (3-6 miles) per session with 3 or 4 sessions each week.

Based on an experience of 15 years, we have arrived at similar conclusions. Men who have been active for 1-3 years run 12-19 miles a week; women normally cover 9-12 miles. Only ardent enthusiasts run 25-30 miles a week.

The intensity of the workout is determined by speed and terrain, and is measured by the pulse rate. To assess the optimum intensity of running, it is essential to account for the energy supply available for muscular activity, or the "anaerobic threshold." This threshold is determined by the level of exertion beyond which the need for oxygen cannot be supplied during the workout, so that energy must be supplied in part by the use of anaerobic energy sources. It is at this point that oxygen-free splitting of glycogen (glycolysis) becomes increasingly prevalent, producing lactic acid and an "oxygen debt."

The intensity of effort at which the anaerobic threshold is reached is called the threshold intensity, while the intensity that corresponds to maximum oxygen consumption is known as the critical intensity. There is a relationship between the intensity of exercise in percentage of maximum oxygen consumption (VO_2), the speed, and the blood level of lactic acid (see figure 13).

As the graph demonstrates, a disproportionate increase in lactic acid occurs at an intensity that equals 80% of maximum oxygen consumption. This intensity corresponds to the level of the anaerobic threshold.

According to the level of the anaerobic threshold and the critical intensity of the exercise, all forms of rhythmic exercises are categorized into one of the

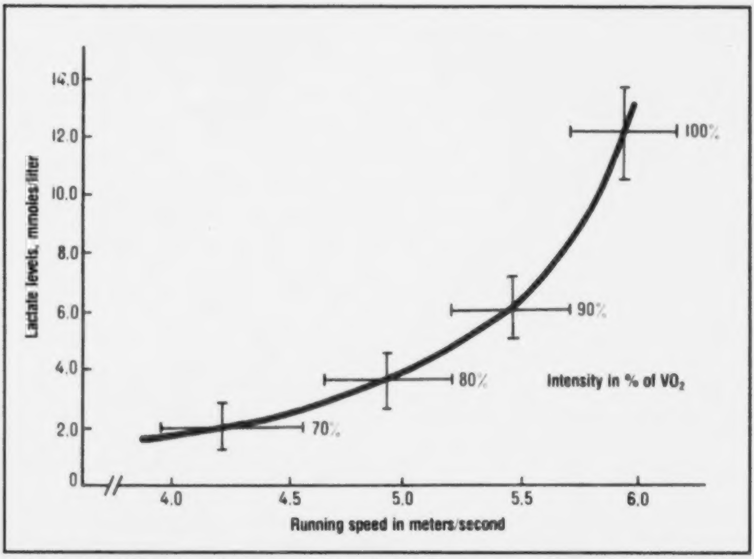


Figure 13. Graph of the relationships between intensity of work in VO_2, running speed, and blood levels of lactic acid [277].

three training zones referring to their type of energy supply: aerobic, anaerobic, or combined.

1. In the aerobic zone of energy supply (pulse rates of 130-150/min), the intensity of work does not exceed the anaerobic threshold, the need for oxygen is fully met, and no oxygen debt occurs.

2. In the "combined" aerobic/anaerobic zone (pulse rates of 150-170/min), the intensity of work lies between the anaerobic threshold and VO_2.

Aerobic sources are not sufficient for complete energy supply; and accordingly, anaerobic mechanisms "kick in"—with breakdown of glycogen and production of lactic acid.

3. In the anaerobic energy supply zone (pulse rates over 180-190/min), the intensity of work exceeds the maximum oxygen consumption (VO_2) level and energy supply is devoid of oxygen—resulting in substantial oxygen debt.

In fitness oriented running, aimed at developing greater endurance, it is sufficient to exercise in the aerobic zone because the physical condition of middle aged, and especially elderly, persons is less than that of athletes. Besides, fitness runners are not interested in achieving high speeds or record performances. Another consideration is that the walls of the coronary arteries lose their elasticity in older people, and thus they cannot accommodate a more intensive training regimen by adequately increasing coronary blood flow.

An additional risk occurs because the heart muscle of older persons has a reduced tolerance for oxygen deficiency, which is inevitable in the anaerobic mode of energy supply. In middle aged inexperienced runners, hypoxia (reduced oxygen) in the heart muscle can cause spasm of the coronary arteries. For all of these reasons, people over 40 should train in the aerobic zone where oxygen supply is abundant. For advanced runners, the maximum intensity of workouts may reach the level of the anaerobic threshold with a slight buildup of lactic acid (up to blood levels of 4 mmol/l). This intensity we define as the border between the aerobic and combined zones of energy supply.

Thus, after 8 weeks of 15 minute training sessions three times a week on a stationary bike, with an intensity corresponding to 4 mmol/l blood lactate levels, healthy subjects aged 30-50 years increased their VO_2 ratings by 14% [346]. Hickson [186] reports a 10-20% improvement in maximum aerobic performance in subjects over 30 after 10 weeks of training in a similar regimen. Only those, however, without any cardiovascular problems should follow such a regimen. In all other cases, the intensity of workouts should remain below the anaerobic threshold.

The anaerobic threshold provides a means of defining not only the limit of running speed in the aerobic zone, but also its maximum duration. Middle aged beginners may perform prolonged work at levels below 50-60% of VO_2; but for advanced runners, this limit can be raised to 75-80% [188, 191]. These data make it possible to generalize that fitness running should proceed at 50-80% of VO_2, depending on the runner's health status and previous experience.

It is well known that the intensity of work and oxygen consumption are directly related to changes in the frequency of the heart rate (figure 14). Special tables have been developed that reflect the relationship between aerobic performance (in % VO_2) and the heart rate (table 12).

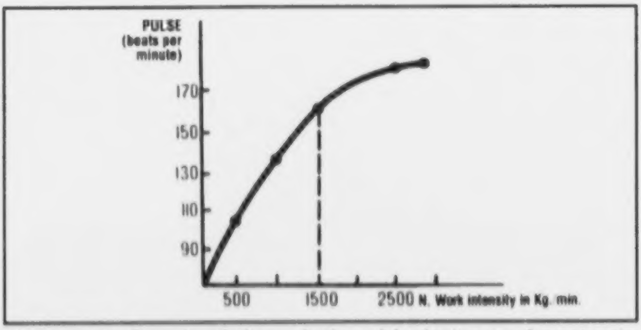


Figure 14. Graph of the relationship between heart rate (f) and work intensity (N).

For example, for a 40 year old male, just beginning to participate in fitness running, the intensity of effort should not exceed 60% of his maximum aerobic performance, which corresponds to a heart rate of 136. As an individual becomes better conditioned over a number of years, the intensity of work will gradually reach 75% of VO_2, which corresponds to a heart rate of 152. For the elderly, an effective workout can be between 40% and 60% of VO_2, because for people over 60, even this moderate intensity results in a 10-14% improvement in aerobic capacity [139]. This is why fast walking at a pulse rate of 110-120 is an effective workout for the elderly.

AEROBIC PERFORMANCE, % OF VO_2	30-39 yrs.		40-49 yrs.		50-59 yrs.		60-69 yrs	
	male	fem.	male	fem.	male	fem.	male	fem.
40	115	120	115	117	111	113	110	112
60	138	143	136	138	131	134	127	130
75	156	160	152	154	145	145	140	142
100	187	189	178	179	170	171	162	163

Table 12. Pulse rates (in beats per minute) at selected workout intensities (in percent of VO_2) according to sex and age: Schephard, 1971 [303].

Various formulas are used for calculating the optimum heart rate, and all of them reflect the relationship between the heart rate and the maximum oxygen consumption (VO_2). The most commonly accepted formula is the one proposed more than 20 years ago by Hollman [187, 190]. According to this formula, the optimum heart rate for beginners is 180 (beats/min) minus the person's age. Thus, for a 40 year old man, the optimum heart rate is 140 beats/min (180 minus 40), which corresponds to 60% of VO_2.

For experienced runners, a higher intensity workout is acceptable. Thus, the final figure can later be increased by 10 beats (to 75% of VO_2). For these individuals, the optimum heart rate may also be calculated according to the formula proposed by a former marathon runner and well known expert on fitness running, Israel of the East German Republic [195, 305]: f = 170 minus one/half of the runner's age. Thus, for a 40 year old well-trained male, the optimum heart rate would be 150/min (170 minus half of age 40 or 170 minus 20).

Training of advanced runners at pulse rates below 130 is less effective and does not produce very much improvement in conditioning. This is because a significant increase in the heart's stroke volume occurs only at pulse rates of at least 130 [35]. At less intense levels of exertion, the heart does not employ all of its reserve capability. However, for people with cardiovascular disease, it is best to keep running intensity in the pulse range of 110-120.

Thus, based on the intensity of the running, as measured by the pulse rate, three stages can be distinguished in the aerobic zone:

STAGE I: Rehabilitation and recovery—Pulse of 110-120. This stage is suitable for individuals with cardiovascular disease, as well as for the elderly and recovering patients as a means of rehabilitation and preparation for training. Stage I is also used by advanced runners as a recovery after intensive training workouts.

STAGE II: Pulse of 130-140. This stage is recommended for beginners as a technique for developing endurance, and for advanced runners as a means of maintaining an already-achieved level of performance.

STAGE III: Pulse of 144-156. This stage should be used only by well trained runners with many years of experience, for increasing their level of conditioning.

The most accurate method of measuring the pulse rate is to take the reading within the first 10 seconds after completing a run; otherwise the reading will be incorrect [191]. Readings obtained within the first 10 seconds have been shown to correspond well with the results of telemetric pulse monitoring during exercise [347]. Pulse monitoring is imperative only in the early instructional stages of fitness running, in order to select the proper speed and optimum workout schedule. Later on, there is no need for such monitoring because experienced runners can control their intensity well by means of a unique feeling of "ease," which indicates the aerobic character of the exercise. This is why Leedyard's principle, "Run easy!" is so important. The sensation of heaviness that normally appears when accelerating or running uphill indicates a shift to the combined zone of energy supply. At this point, the heart rate reaches 150-160 and middle aged runners are advised not to exceed this limit.

Breathing characteristics are also a measure of intensity. Our studies show that the method of breathing closely reflects the intensity of exertion and the corresponding zone of the training regimen. Thus, during tests on a stationary bike with graded increases in effort, subjects were able to maintain normal and strictly nasal breathing during low level exertion; but as each subject reached the moment when she/he had to inhale orally, the pulse rate was documented—and these transitions from nasal to oral-nasal breathing occurred in the pulse range of 130-160. Furthermore, the better the conditioning of a subject, the higher was the pulse rate at which breathing switched to a combined oral-nasal type (table 13).

Increasing running speed causes a transition to the combined type of breathing, which is accompanied by an excessive increase in pulmonary ventilation, and this is identified as a criterion for the upper limit of the aerobic zone — corresponding to the "anaerobic threshold" [53]. For this reason, beginners are advised to maintain nasal breathing (provided they have a healthy naso-pharyneal passage), which imperatively limits speed and makes

EXPERIENCE	WEEKLY MILEAGE	HEART RATE AT THE MOMENT OF SWITCHING FROM NASAL TO ORAL-NASAL BREATHING
6–12 Months	10–12.5	130–140
1–2 Years	12.5–19	140–150
Over 3 Years	19–25	150–160

Table 13. Relationship between type of breathing and pulse rate comparing runners of different fitness levels during workouts on a stationary bicycle.

running safer. Forced transition to the combined type of breathing in beginners indicates that the optimum speed has been exceeded and the runner has crossed the boundary of the aerobic zone.

Experienced runners normally prefer training at a higher speed, maintaining both nasal and oral breathing, exercising at the boundary of the combined zone of energy supply. This practice supports an interesting study conducted by Canadian researchers. During a 10 kilometer race, the breathing of 984 male and female runners of various ages was videotaped. Analysis of the tape showed that 96% of the participants were breathing through both the nose and mouth [267].

In some sports, such as swimming and rowing, breathing has to be coordinated with rhythm of movements. Apparently for the same reason, in running too it is often recommended to coordinate breathing with striding—one respiratory movement (inhale OR exhale) per two cycles of movement (2 strides), for example, inhale for 2 strides, exhale for 3 or 4 strides. But actual practice suggests that such an artificial imposition of a breathing pattern is neither effective nor beneficial.

In this respect, one cannot disagree with New Zealand's former outstanding athlete and coach, Arthur Leedyard, who said: "There are no set rules for long distance running. I do not teach the system of rhythmic breathing developed by the Finns, where you start with 4 strides for inhaling and 2 for exhaling, with subsequent increment in the number of strides per inhalation up to 8 and the number of strides per exhalation up to 6. I think this pattern makes running somewhat artificial. When running, you are going to need large amounts of oxygen; and it is unimportant how you take it in."

Another of the indicators for the correctness of one's exertion level is "talking speed"—meaning that runners can converse with ease during the workout. If a runner starts gasping and replying with isolated words that means the speed is above optimum.

Another important indicator of intensity is the so-called "perceived level of exertion." Since this parameter is impossible to calculate for an individual, it is usually compared with the heart rate. A middle aged experienced runner who runs at full speed can reach a heart rate of 170-180. Accordingly, running at a speed just under this limit, at 150-160, can be taken as "three-quarters exertion"; prolonged running on a highway at 130-140 as "half-exertion"; and light warm-up jogging at a pulse under 130 as "one-quarter exertion."

This is why middle aged and especially elderly people should abstain from running at full speed, as in competitions, or in the classic Cooper 12-minute test. For these people, the best results in a long distance event should be at "three-quarters exertion" at most, while a prolonged Sunday run should proceed at "one-half exertion."

STAGES OF TRAINING

An instructional course in the basics of fitness running as well as the stages of training will vary according to the health, conditioning, and age of the participants. Let's examine some generalized instructional patterns for beginners. For this purpose, we will assign all the prospective runners to one of three groups: Special, Preparatory, and Main.

SPECIAL GROUP: These are individuals with serious health disorders, for whom running is contraindicated at first. Training for this group consists of two stages:

First stage— Walking at a normal pace for 20 minutes. Two walks can be taken daily if the health condition permits. Gradually, over a period of a few weeks, the length of these walks can be prolonged to 30 minutes, after which the workout remains unchanged for a period of time. Then, if the health condition is stable, the length of the walks can be increased up to one hour. Individually this process may take from 1 to 6 months. Walking speed remains the same at all times. The heart rate at this stage is expected to be between 84 and 96.

Second stage— Fitness walking. The pace is faster than in the first stage, yet should impose no strain. The exercise begins with walking for 10-15 minutes, followed by a period of accelerated walking, and concludes with an additional 10 minutes of relaxed walking. Initially, the distance for the accelerated walking is a quarter mile to one full mile. The authors object to assigning the workout by a number of strides per minute. The speed should be increased only naturally by means of the training effect. Breathing should be involuntary, but optimally nasal breathing. If you are forced to breathe orally, you should slow down. Walking speed can also be governed by monitoring the pulse, which should be between 104 and 120.

If the health condition permits, the distance for fitness walking can be increased over a few weeks to 1.25-2 miles; and over 4-6 months this distance can be extended to 3-3.75 miles, and up to 6.25 miles (10 kilometers) over one year.

Fitness walking differs considerably in technique from relaxed walking and is more like "race-walking." *

The transition from walking to fitness walking should be done gradually so that a patient adjusts to the new technique. Accelerated walking exercises should be performed once daily 4-5 times a week.

During the course of the protocol, walking speed may be gradually increased so that it will reach 3-3.75 miles per hour over a year. The exercise can be "controlled" (monitored for effectiveness) by measuring the time required to cover a given distance. The best way to do this is to select a course where the terrain is level and where the start and finish points are well defined. When time is limited, the workout can be performed while walking to and from work (up to 6.25 miles). It's a good bet that such regular workouts will improve, whatever the health condition is, enough that running can be introduced later on.

PREPARATORY GROUP: These are the beginners over 40 years old and individuals of any age with mild health problems.

First stage— Fitness walking. The relaxed walking stage is omitted. The initial distance is set at 1-1.25 miles, depending on the health condition. Each individual selects his/her optimum speed without trying to compete with other people in the group. Target heart rate is 110-120. The pulse is measured several times during the workout and at the finish. If the heart rate exceeds the allowable range, the speed should be reduced.

If the participants adjust to these workouts after three weeks (speed increases at a given heart rate, or heart rate drops at a given speed), the distance can be extended to 1.5 miles and, after two more weeks, to 1.75–2 miles. This regimen is then maintained until they can walk effortlessly for 2 miles (8 laps on a stadium track) in 30 minutes, which is 3.75–4 miles per hour at a heart rate no greater than 120.

Second stage—Combined running and walking. After the first stage has been mastered and if the health condition is stable, short stretches of running can be introduced: 60-100 feet following 500-660 feet of walking. In one lap (each quarter-mile), two "runs" can be taken, with the heart rate reaching up to 132. If the heart rate is higher, then the bursts of running should be shortened, and the stretches of walking lengthened, and/or the running speed should be reduced.

In the course of the training, the running stretches will be gradually extended without any noticeable effort on the part of the runner, and walking will be reduced to the point where running will become continuous. The period required for this transition will vary and will depend on the health con-

---

*The technique of fitness walking has been described by D.D. Donskoi in the journal *Legkaya Atletika*, 1986, No. 2, pp. 15-18.

dition and the experience of the participant. It may take anywhere from a few months to a few years of dedicated exercise.

Third stage—Continuous running. When you have mastered running for 2 miles without discomfort, the time for the exercise can be extended to 30 or 40 minutes and later, to one hour. Running speed should remain the same at all times. Once you have discovered your optimum speed, you should hold it at the same level. We recommend against "timing yourself" too often, as it can cause you to increase your speed inadvertently and will create anxiety and take the pleasure out of the workout. People over 40 may want to stop at this stage since 3-4 sessions per week at 30-60 minutes each is an adequate protocol for health improvement and prevention of cardiovascular disease.

MAIN GROUP: These are all healthy individuals under the age of 40.

First stage—"Run-walk." Workouts begin with alternate running and walking for 1.25-1.5 miles. In each lap (quarter-mile), one or two runs of 100-160 feet each are done. The speed and length of the running segments are individual and are selected so that the heart rate does not exceed 132-144. If the pulse rate is higher than this, the distance or the speed of the runs should be reduced. Individuals in good health may increase the distance to 2 miles after 3-4 weeks.

Second stage—Continuous running. The distance of 2 miles is continued until the running becomes continuous. (Transition to continuous running will depend in each case on individual fitness.) Then the duration of running is gradually increased to 30-60 minutes. At the end of the first year of regular workouts, the distance may reach 3 miles for women and 6 miles for men.

Third stage—"Marathon running." Many runners will not be content with a basic training schedule and, over a number of years, will increase their Sunday exercise to 1.5-2 hours. Running speed at this stage is usually higher and reaches 6-7 miles per hour for women and 7-8 miles per hour for men, while maintaining the same target heart rates of 132-144.

Experienced runners under 40 may follow the "sports protocol" of training, combining the "steady mode" with the "interval mode," i.e., accelerating several times for a quarter to half mile during the second half of the workout. This can result in heart rates that reach the combined zone of energy support, at 160-170. For fitness running, this regimen should be used no more than once a week, when preparing for a competition or a race.

PLANNING YOUR TRAINING

Correct planning of weekly and monthly workouts is essential for achieving health benefits. The specifics of postexercise recovery are the biological basis of this planning. While additional training before full recovery is occasionally justified for athletes, in fitness running, this kind of "tough" regimen is unacceptable. Beginners need at least two or even three days for full recovery. That's why they should exercise no more than 3 times per week [122, 220].

Based on observations over many years, we recommend the following approximate schedules for a two week training cycle, depending on individual experience and fitness level (table 14).

	FIRST WEEK *							SECOND WEEK*						
EXPERIENCE	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Under 6 Mos.			20		20		30			20		20		30
6–12 Months:			30		30		40			30		30		40
1–2 Years:		20	30		30		60		20	30		30		40
3–5 Years:		30	60		40		120		20	60		40		90

*Translator's note: In the Russian way of thinking (and on the Russian calendar) the week begins on Monday and Sunday is the seventh day. This will clarify table 14 and reconcile the frequent references in the text to "Sunday runs," meaning that Sunday is the day Soviet runners reserve for their "long run."

Table 14. Approximate distribution of workouts over a two week microcycle considering the experience/fitness factor (minutes).

Depending on health and experience, the increase in "training load" can lag behind this schedule or exceed it. But the pattern of alternating workouts and rest days should not be changed. Workout time is an individual matter and thus will differ even for healthy individuals. Here are a few examples.

E. M., a healthy lady of 34, has been in the Club for 5 years. She began training with a run-walk protocol of 1.25 miles at a pulse of 144-152. At the end of her first year of regular workouts, she was able to increase her distance of continuous running to only 1.8 miles, and after 5 years, to only 3 miles.

A. B., a healthy gentleman of 38, had never participated in sports. He also began training with a run-walk protocol, but after 3 months was able to run 6.25 miles (10 kilometers) with ease and, after 6 months, completed a 12.5 mile race ("half- marathon") in 1 hour 20 minutes!

The cardinal principle in designing a weekly training cycle (microcycle) is to alternate high, medium, and low mileage, thus providing a better recovery of body functions. Since 15-20 minutes of continuous running in the initial stage is a sufficient workout for beginners, the duration of the workout does not vary at the beginning. After about 6-12 months, when the workout has been mastered, a much greater effort (near maximal or even beyond) is added to the microcycle. It is this effort that will provide the basis for further development of a runner. Full recovery after such a workout is extended over a 5-6 day period. "Regardless of how excruciating a Sunday run is, after 7-10 days I feel much stronger," says Leedyard.

After a few years of regular training, when the duration of the Sunday workout reaches 1-2 hours, for the sake of preventing overtraining, it is time to switch to a two week microcycle, with alternation of Sunday's high training loads: On the first Sunday, the duration of the workout is near maximum, while it is 30-50% less on the second Sunday. If an individual feels comfortable, one more session can be added on Tuesday—very light and not prolonged. This light workout promotes a faster recovery after the Sunday run and serves as a warm-up for Wednesday's effort.

If recovery takes longer because of a specific lifestyle, the training cycle can be extended to 4 weeks. In that case, the maximum-duration workout (e.g., a 12-15 mile run) is scheduled only once a month.

Well-conditioned runners with many years of experience can vary their workouts not only by distance, but also by intensity. Thus, the long Sunday run should be carried out over level terrain with a heart rate not exceeding 130-140. Another shorter but faster run (on Wednesday, for example) should proceed at a pulse of 144-156, with a third short and easy run (e.g., on Friday) at 120-130.

If advanced runners experience a strong feeling of fatigue after the Sunday run, then the Friday workout should be limited—so as to be invigorating, and so the runner will finish it with a desire to run more. By doing this, the runner has a chance to fully recover by Sunday. High duration or high intensity workouts on Friday are undesirable because they endanger the Sunday workout.

We recommend that training not exceed three or four times a week. Some runners, however, are able to work out every day and yet feel very well—with no signs of overtraining. The reason for this is that such daily running consists of only moderate or low intensity workouts which, compared with more strenuous workouts, cause much less fatigue. Full recovery is usually achieved overnight after this type of workout—in time for the next day's effort. Yet the training effect is somewhat limited in this type of training. That is why running three times a week for one hour is more effective than six times a week for 30 minutes, even though the weekly "training load" would be the same.

Daily running can be preferable when there is no emphasis on "high performance," and when the objective is rather on maintaining health and the present level of fitness, as, for example, in the case of people over 50 or 60 years old. Apparently this is why a short daily run is so successful for the elderly. They are retired from work and have a better chance to completely rest and recover. If you are comfortable with daily running, there is no need to discontinue this practice.

We've received many letters attesting to the perils of heavy daily workouts for people in their thirties and forties. Here are excerpts from some of them:

"I am 35 and I've been running for 4 years. I used to exercise every other day, but in the past year I started to run 6-7.5 miles a day according to the Leedyard system. Toward the end of the year, heart pain appeared and my overall condition worsened. Doctors examined me and diagnosed a condition of excess strain on my heart. I was given various medicines, but it's been several months now and there is no improvement. I have a heart pain and can no longer run."

"I have been running for more than a year; however, after an initial period of high morale and feeling good physically, I began to feel very tired, I was frequently ill, and I felt depressed most of the time. I was at a loss! Running was supposed to drive away ailments! On your advice, I changed to running every other day and I am now feeling happy and healthy again."

Here is another letter describing the state of overtraining:

"I've lost sleep completely; and, when I do fall asleep it is more like drowsiness. I am constantly bothered by discomfort in the heart area. Generally, I feel listless and depressed. In dealing with other people, I feel anxious, even in situations which are not stressful. I used to walk with an erect posture, but now I am stoop shouldered and I've lost weight. My pulse rate is rapid; not only after exertion, but also at rest. Things have been like this for three months and nothing seems to help."

This is why you should not ignore your body's signals (sleep disorders, etc.); you should reduce your workout load immediately when signs of overtraining appear. If you act promptly, overtraining can be avoided.

To prevent overtraining, it is helpful to reduce the workout schedule for a few weeks two or three times each year, so as not to keep your body under constant stress. A good time to do this is after the summer season, which is filled with many running events, and also in the spring (February and March), when your body does not get as many vitamins and microelements. There is no risk of "falling out of shape."

Hickson and her team [186] at the University of Chicago found that when advanced middle aged runners reduced their training load by 30% or even 60% for 15 weeks, the drop in their endurance level was negligible. Their timed exercise tolerance decreased by only 10%, while the mass of the left ventricle, cardiac stroke volume, and the level of VO_2 remained at their previous high levels. Thus periodic reduction of workouts in the annual training cycle makes sense for fitness runners. Equally effective is a brief switch over to some other rhythmic sport: skiing in winter and bicycling or swimming in summer. This will also break the monotony of year-round running.

In the laboratory of Soviet Academician V. P. Chernigovsky an experiment was conducted involving stimulation of nerve endings in animals, which caused certain changes in circulation and respiration. While at first the stimuli caused an increase in functions, it is remarkable that later the effect of the stimuli was greatly diminished. This phenomenon was named "habituation" and is explained by adaptation of the nerve centers to a given constant stimulus.

A similar phenomenon has also been observed in sports physiology: prolonged use of a local rehabilitative technique, e.g., massage of isolated groups of muscles, makes it less effective. After a certain point, habituation occurs.

For this reason, a workout schedule should be constantly increasing if our objective is to improve physical fitness.

After you have become able to run continuously for 30-40 minutes, increase the workout no more than once or twice a year—in the spring and fall—on only one day of the weekly microcycle. Thus at first the duration of the workout is increased to one hour, and later to its maximum (1.5-2 hours) on Sunday. On the other days of the week, the workout is not changed.

For example, if you have mastered a 6 mile run in the course of the first year, try to run 8-9 miles on one or two Sundays every month, and ultimately, alternate runs of 6 and 9 miles on Sundays. After about 6 months, when you are used to this effort and it causes you no undue fatigue, you can alternate 9 and 12 mile distances on Sundays, and in another year or two, these distances can be increased to 12-15 miles. Thus in the course of a few years, you will comfortably reach a distance of 18 miles—and this distance you should not exceed.

The duration of cross country running (on Wednesday) is also gradually increased up to 1 hour (by increments of 0.6 mile per year). When you are well adjusted to this effort, you can increase the duration of the Friday workout and add one more session on Tuesday. We stress again that the time each individual may require to reach his or her optimum volume of training will vary, and it is a mistake to hurry or try to compete with stronger runners.

Running enthusiasts will want to know: What is next, after the limit has been achieved? Will I develop "habituation" and what effect will it have on my health?

It is true that after the workout schedule levels off, the development of aerobic potential may cease, and speed and endurance will remain unchanged. However, this situation will still provide maintenance of good health and fitness, since the workouts will still involve the needed energy consumption and stimulate carbohydrate and fat metabolism as well as stimulation of hormonal secretion, cardiac activity, vasodilation (blood pressure reduction), and mood elevation. What else could we ask for—beyond maintaining a high level of fitness and creativity? Staying young is what running provides! As for record performances and triumphs in competition, these things we will leave to the Olympians.

N. S. joined the club when she was 54. After 5 years of following all the rules of training, she reached her optimum workout schedule of 18-25 miles of slow running each week, after which she did not increase her workouts. And yet, based on the PWC_{170} test, she had the highest level of physical performance among all the women in the club—some of them much younger than she. For the past three years in a row she has been among the prize winners in her age group for the 6.25 mile (10 kilometer) run. She has no health problems; she still works, cares for her grandchildren, and is active in promoting fitness running.

The calisthenics regimen developed by Academician N.M. Amosov, a well-known scientist and champion of physical exercise, is worth imitating: 1.8-2.5 miles of slow running plus exercises for the joints (Amisov's famous "Thousand Movements") enable him at his age of over 70 years to perform almost the same amount of both physical and creative work as he did in his younger years.

Training consists of not only the workout itself, but also the subsequent rest period during which many recovery processes take place that provide for further conditioning of the body. (The period following the workout is sometimes called the "constructive" period.) If the rest period is too short, these processes are disrupted. This is why it is so important to rest properly.

Getting at least eight hours of sleep each night is of critical importance. In this respect, one of the best methods is that of "autogenous training" which teaches the inducement of states of rest, heaviness, and warmth. It is discussed in a book by A. Lindemann, *Autogenous Training* (published in *Phizkultura I Sport*, 1985). Psychoregulation training, presented in A.V. Alekseev's book, *Transcending Yourself* (*Phizkultura I Sport*, 1985), has been developed specifically for athletes.

Sleep by autosuggestion is especially effective. It is a method that has been studied for a number of years in the Physiology Department of the Smolensk Institute of Physical Culture (V. M. Volkov, E. G. Milner, 1980) [18]. Using this method, 10-15 minutes after the beginning of an autosuggestion session, a subject falls into a light sleep for 20-30 minutes. With this method, full performance capacity is restored much sooner than after a passive rest. Athletes use self-induced sleep 1-2 hours after a "high performance" workout that results in fatigue. This performance enhancing technique can also be used successfully by amateur fitness runners following a prolonged Sunday run.

The rest in the training microcycle should be just as rigidly planned as the workout schedule. It is essential to rest fully before and after the big Sunday run—i.e., on Saturday and Monday. A steam bath can be a good idea on Monday or Friday, when the workouts are minimal, while on Saturday or Sunday it would be undesirable. A steam bath prior to the Sunday run causes a prolonged muscle relaxation resulting in a feeling of heaviness during the run. Furthermore, on the day of a long workout, a steam bath may delay the recovery process. For these reasons, it is recomended to take a warm shower after the long Sunday run and a hot bath before going to bed, when circulation has returned to normal. This will enable the fatigued muscles to relax and rest.

Experienced runners burn up large amounts of protein and other essential substances such as vitamins and microelements, and they should thus make sure that their nutrition is adequate. (There will be more on nutrition in Chapter Four.)

Only by observing these rules and seeking the optimum combination of work and rest can you expect training to be highly effective.

PROBLEMS ENCOUNTERED IN MARATHON RUNNING

Let's suppose you have reached your optimum workout limit, and longer distances are not called for. This average optimum can range between 12 and 18 miles of slow running per week. But this is only an average! There is a wide variation among individuals. Each runner has his/her own optimum and own limit. The purpose for exercising may also be different in each case. The majority of people over 40 are quite content with the optimum workout schedule that enables them to function normally and enjoy running. The objective is to preserve our health.

But excelling and reaching for previously inaccessible heights is an inherent human quality. In order to taste the complete running experience, many people turn to marathon, the longest of the classic running distances. It is based on the distance run by Phidippides, an Athenian courier, who was dispatched to secure Spartan help upon news of the Persian landing at Marathon in 490 B.C. Still, the centuries that separate us from this legendary runner do not diminish the magic attraction of the marathon.

The numbers of marathon runners participating in one marathon competition are sometimes enormous—ten, twenty, even forty thousand people! A. Sandebrant, president of the Stockholm Running Club, called the marathon the distance of the century. People of all ages participate in marathon. But one should be very careful and learn the problems of marathon running before engaging in this activity.

Twenty years after the appearance of his first book, *Running for Life*, Garth Gillmore, a well-known journalist from New Zealand, had to admit that accomplishing a marathon distance is not necessarily essential for improving health.

A newer classification of endurance running proposed in 1984 by the German scientist, G. Neuman [264], is quite deserving of our interest: Three categories or "zones" of endurance are distinguished, based on distance. In the first zone (up to 30 minutes of running), energy is fully provided by carbohydrates, consumption of glycogen is low, no biochemical changes are present in the blood, and there is almost no impact on the cardiovascular system. In the second zone (60-120 minutes), energy is already being actively supplied by fats. Yet in the well-conditioned runner, the blood chemistry and EKG are essentially normal.

When running in the third zone (120-360 minutes), the supply of muscular glycogen becomes depleted, and therefore, not only does fat oxidation increase, but proteins are consumed as well. As a result, toxic breakdown products (ketone bodies) accumulate in the blood. Since the oxidation of fat requires more oxygen than the oxidation of carbohydrates, there is a buildup of incompletely oxidized substances in the blood, which may result in acidosis—i.e., acid reaction of the blood. The moment of the sharp increase in fat participation in the energy supply, caused by the shortage of glycogen in inexperienced runners, is usually marked by a reduction in speed. The whole point of marathon training is to train the body to overcome this condition painlessly.

Running enthusiasts who dare to run a marathon, which usually takes them 3-4 hours or more, demonstrate metabolic disturbances including ketosis, lactic acidosis, and unfavorable changes in the cardiovascular system. Studies done on participants in the Boston and New York marathons revealed increased blood levels of the enzyme creatinine phosphokinase [289], which is indicative of disrupted cell membrane permeability caused by hypoxia of the heart muscle [79]. This condition combined with ECG changes is possibly a reflection of heart muscle damage caused by an excessive secretion of catecholamines—adrenalin and norepinephrine [222].

An attempt to complete a marathon distance is especially dangerous if the temperature and/or humidity is high. The reason for this is that, even with ample perspiration (up to 3-5 quarts) and heat emission (evaporation of 1 quart of sweat gets rid of 500 kcal), body temperature can still reach critical levels during the run. Thus, continuous telemetric measurement of rectal temperature in participants in the Boston Marathon has shown that rectal temperature rises to 102° on the average [82, 125] and occasionally reaches 104°-106° [241]. Such overheating drastically reduces performance, makes running burdensome, and can lead to heat stroke.

In July 1984, we, the authors, organized a run on the Moscow-Minsk highway, bound for the border between the Russian and Byelorussian Republics, to celebrate a holiday. July of that year was unusually cold and rainy, but on the day of the run, it was sunny with temperatures reaching 80°C in the shade at noon. We began the 18 mile run at 10 a.m. We were followed by a bus carrying our devoted "bodyguard," T.A. Mazurina. Just before the start, it rained and steam from the pavement added to the stuffy conditions.

About noon, we felt that the heat was becoming unbearable. Not far from the finish, on the 17th mile, we came upon a man in his running gear, prostrate on the road. It was Valentin N., one of our strongest and most reliable marathoners, a participant in the Moscow Peace Marathon. He was staring blankly into the air, his arms and legs were shaking spastically, his breathing was raspy and irregular, and his pulse was not palpable. It was Valentin's luck that a former anesthesiologist happened to be there. In 20 minutes we were in the hospital, and the next day, Valentin was sent home safe and sound.

Marathon running is hardly justified for fitness purposes, primarily because of the possiblilty of strain on the cardiovascular system. Even our limited experience in studying marathon running provides a case of "overstressed heart" in a quite young runner.

N.V., age 26, is a former athlete, who took up fitness running. After two years, he had built up his workout schedule to 37-50 miles a week. However, during the 3 months of training preparatory to the Moscow Peace Marathon in

1985, N.V.'s ECG revealed signs of acute third degree overstress of the heart muscle—inversion of the T waves in all leads (figure 15). With reduction in the workout schedule and appropriate treatment, these changes rapidly disappeared.

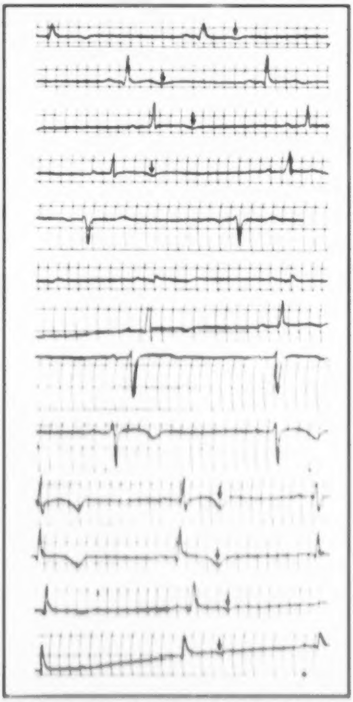


Figure 15: ECG of N.V. at the end of 3 months preparatory training prior to the 1985 Moscow Peace Marathon. T waves are inverted in all leads (as indicated by arrows).

In our running club, a definite protocol has been developed with respect to the marathon: First, only absolutely healthy, experienced individuals, who can do a 15-18 mile run without undue strain or special training, are allowed to run in a marathon. Second, participation in a marathon is allowed no more than once a year. Third, a special training schedule has been developed that reduces fatigue and overstraining of the cardiovascular and musculo-skeletal systems. This special training schedule calls for no change in the "training load" during the week, but demands a gradual increase in the Sunday run over 2-3 months from 15 miles to 22-25 miles. On the other days of the week, the workout schedule is unchanged and calls for no more than 31 miles on the average, which is only half of the total distance recommended by American authors [109].

Once every 4-5 weeks, a run of maximum duration is called for, with a gradual increase of the distance up to marathon distance or slightly less. An approximate schedule of a 12 week marathon training schedule is shown in table 15.

	WEEKS			
MONTHS	1	2	3	4
First	20	30	20	35
Second	20	30	20	38-40
Third	20	30	20	42

Table 15. Distance of Sunday runs in kilometers.

Experienced marathon runners may slightly shorten their preparatory schedule. The first timed run for 35 km (22 miles) is 8 weeks prior to the marathon, with a second run of 38 km (24 miles) four weeks later.

This makes it possible to avoid overstraining and, at the same time, acquire an adequate level of conditioning. If, however, a person is not used to running 22-24 miles, the marathon will become a torture. Statistics from the Boston and New York marathons support this, indicating that over half of the participants entered have not reached the finish line, while many of them have required emergency medical assistance.

Proper tactics in running the marathon are also important for success. In contrast to the athlete, the correct tactic for a fitness runner means only one thing: to run the entire distance at your optimum (not maximum) speed. Any attempt to vary this speed will dearly cost the careless marathon runner.

It is best to run the first half of the distance slightly slower than your average speed and to increase it in the second half. After 22 miles, the speed will drop again, which is the inevitable destiny of both the accomplished athlete and the grey haired marathon enthusiast. Yet physical and psychological stability under the stress of a marathon run will vary according to conditioning. For this reason, dedicated training is essential before a marathon event.

FITNESS RUNNING AND COMPETITION

Since competitions are more a sport than a fitness endeavor, one can do without them as far as health is concerned. This is especially true when we consider that competition, very much unlike training sessions, calls for maximal effort and mobilization of all the resources and systems of the body.

However, the truly "mass" character of the fitness movement has created a demand for various events—competitions and races. And such competitions for fitness runners must be different from sports competitions. First of all, do not set a "super goal" for yourself—catch up, pass someone, win! Your minimum objective is to run the entire distance at the speed you are used to. Your maximum objective is to repeat your "best time" or slightly improve upon it.

Beginners with no health problems may participate in 3-6 mile races; experienced runners may go for 12 miles, and "aces" can indulge in 18 mile (30 km) runs that nicely replace the classic marathon distance of 26.37 miles. Running 3-6 miles requires no special training, provided you run regularly throughout the year.

To train for a 12-18 mile (20 or 30 km) event, a 2 week microcycle is sufficient for experienced runners. Two weeks before the event, a long, steady run is done, of equal or slightly longer distance than the event you are training for. One week before the event, a light run is called for, approximately two-thirds of the distance being trained for. During the last few days prior to the competition, the workout schedule should be lower than usual. This enables the body to recover completely and emerge into a phase of "supercompensation," i.e., of enhanced performance.

Those who have accomplished the 12 mile distance and want to run an 18 mile (30 km) event for the first time, may try the following 8 week training cycle, increasing the duration of the Sunday runs according to table 16. On the other days of the week, the workout schedule is not changed, thus avoiding an excessive increase in "workout load" or undue stress on the cardiovascular and musculo-skeletal systems.

WEEK	1	2	3	4	5	6	7	8
Training Distance	20	25	20	30	20	25	20	"Event" of 30 km

Table 16. Distance of Sunday runs 8 weeks prior to a 30 km (18 mi) competition (in kilometers).

Young healthy people and athletes who have recently retired from competition may engage in a more strenuous pre-marathon protocol. Its main difference is that, for development of speed, sprinting for 100 to 1,000 foot stretches is introduced into the weekly cycle, thus using both the interval and alternating methods of training.

Half-marathons are becoming increasingly popular abroad. In the USSR also, these 13-mile events are being held. Those who want to try a half-marathon, and who have already completed 6 mile (10 km) events, may find it useful to try a special training method that was published in the American magazine *Runner.* This protocol is designed for 5 weeks and excludes the kind of short distance speed exercises that are typical for the training of athletes. The emphasis is placed on gradually increasing the speed of the long distance run on Fridays (table 17).

Day	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5
SUNDAY	24 km easy	19 km easy	19 km easy	19 km easy	18 km easy
MONDAY	REST	REST	REST	REST	REST
TUESDAY	6-7 km easy	6.5 km medium 1.5 km @ race pace	6.5 km medium 1.5 km @ race pace	6-7 km easy	8 km medium 1.5 km @ race pace
WEDNESDAY	10 km easy	12 km easy	13 km easy	14 km easy	16 km easy
THURSDAY	6 km easy	8 km easy	8 km easy	10 km easy	16 km easy
FRIDAY	10 km @ race pace	12 km @ race pace	12 km @ race pace	13 km @ race pace	6 km-Very easy!
SATURDAY	6 km easy	6 km easy	6 km easy	7 km easy	REST

Table 17. Chart of the pre-event training schedule for a 13 mile event ("half marathon") for advanced fitness runners: from Legkaya Atletika, 1985, No. 5.

Daniels and Gilbert have reported the approximate correlation between the "performance times" for the 6 mile (10 km) run, the half-marathon, and the marathon (table 18).

10 Kilometers	Half-marathon	Marathon
30.25	1:07	2:20
34.00	1:15	2:37
40.40	1:30	3:07
45.11	1:40	3:28
54:14	2:00	4:08
63:25	2:20	4:48

Table 18. Equivalent "performance times" for 10 kilometers, half-marathon, and marathon.

Breaking records should never be a project for a fitness runner, even for those who are young and healthy. Participation! that's the important thing!

RUNNING AND SELF-MANAGEMENT FUNCTIONAL TESTS

No training scheme or method of working out will be effective without constant monitoring of the body's condition. For this purpose, some simple methods of self-monitoring can be used successfully, as well as more complicated tests requiring a medical clinic or laboratory setting.

One can judge the condition of the body by four simple and accessible indicators: pulse rate, sleep, feeling of well-being, and working capacity.

The most objective indicator is the pulse rate. Counting the pulse for the first 10 seconds after a run or walk allows one to judge the intensity of the workout. The total "training load" of one workout (volume plus intensity) can be evaluated by the speed of recovery of the pulse rate. If the effort corresponds to the functional capability of the body, then ten minutes after the finish the pulse rate should be less than 100 beats per minute (not more than 16 for 10 seconds).

Also, according to our observations, valuable information about the adequacy of one's effort is given by the pulse count one hour after the workout. If the effort was not excessive, then the pulse rate at that stage of recovery should approach the starting (resting) value. For example, if the pulse rate was 60/min before a run, then one hour after the run it should be between 60-70. In experienced runners after a long run (for example, 30-35 kilometers or a marathon), the pulse rate may not return to normal values till the next morning. If the pulse is still too fast even on the following day, it means that you are not yet ready for that kind of run.

An index of recovery was also proposed by the English researchers Humphries and Holman in 1984 [191]. The pulse rate is taken after an ordinary effort (a 5 or 10 km run) for the first 10 seconds after the run and for the last 10 seconds of the second minute of recovery, converted to beats per minute (by multiplying x 6). The index of recovery is defined as: the difference between (subtract) the pulse rate immediately post exercise and the pulse rate at 2 minutes. For example, for the first 10 seconds after a run the pulse measures 25 beats, and for the last 10 seconds of the second minute measures 20 beats. In this case, the index of recovery = (25 x 6) − (20 x 6) = 30. With an increase in conditioning, according to the data of the authors, the index increases, so even though the speed at a given distance might be greater, and the pulse rate higher at the finish, still the recovery is faster. Therefore, regular use of this test in the course of a year gives an objective measure of the effectivenes of training.

Data reflecting the total amount of effort for a weekly or monthly cycle of training and degree of recovery of work tolerance are obtained by daily measuring of the pulse rate before arising in the morning, while lying flat, immediately after a night of sleep. If the daily differences in pulse rate do not exceed 2-4 beats per minute, it means that your workout load corresponds with your capabilities and your level of training is rather high. In the case of irregular exercise and insufficient adaptation to endurance training, the variation in the pulse can be larger than that value, especially when there is unstable atmospheric pressure or chronic fatigue.

The "orthostatic test" also gives quite complete information. When adaptation to workouts is good, the difference in the upright and recumbent pulse rates should not exceed 12 beats per minute. Pulse is determined first in the recumbent position, and then one minute after assuming the upright position. If there is a difference of 16-20 beats per minute, your functional condition could be considered satisfactory, but if the difference is more than 20, this is proof of overtraining. In this case, it is necessary to skip a few workouts and thereby decrease the total workout load.

No less important indicators are sleep, and the feeling of well-being. Sound, invigorating sleep, quick and easy falling asleep and awakening, good general morale and mood during the course of the work day, cheerfulness and desire to train—these are all reliable symptoms that you've chosen a correct workout load and that it corresponds to your functional ability.

By contrast, sleeping poorly, irritability, sleepiness and fatigue during the day, and lack of desire to get up in the morning or to exercise or run are all symptoms that document "overwork." Usually this means that you have done your daily runs too intensely or your Sunday runs are too long and burdensome. In either case, you must reduce your total workout load. If these early symptoms are ignored and the workout schedule is not promptly adjusted, then "overtraining" sets in with all its consequences—insomnia, reduced work capacity, arrhythmia (irregular heart beat), and susceptibility to various chronic diseases.

Chronic overwork is caused not only by an irrational regime of training, but also by undue daily stresses at work or at home, strenuous mental activity, poor sleep, chronic sleep deficit, and various stress situations. In any case, it's necessary to decrease your total weekly mileage and to reduce the number of workouts so that the total burden on the body won't be excessive.

Determining the status of training of a runner can also be done by a simple calculation of the volume and intensity of workouts in a weekly cycle according to a formula which was proposed by a group of Japanese scientists at the University of Kimomoto [258]:

$$IT = \frac{d\ s\ n}{7} \times 100$$

where IT = index of training
d = duration in minutes of all the workouts in the week
s = average speed of the week's workouts in meters/sec
n = number of workouts in the week.

The greater the index, the greater is the workout burden and the conditioning of the runner.

Using this method, in order to quickly and accurately determine the level of conditioning, one needs to keep a diary of self-management [table 19]. This allows one to work out an optimal system of training and detect the early symptoms of overwork promptly. In the diary, daily notes are kept regarding the quality of sleep, feeling of well-being, desire to train, tolerance for the exertion of the workout, and also work tolerance during the workout as well as in the course of the work day. For easier reading, these notations can be marked in three colors: green—outstanding, blue—good, and black—bad. On the days of workouts, the kilometerage is recorded as well as the duration of the run in minutes. The pulse is noted daily in the morning after sleep and also after each run—both immediately and again at ten minutes.

Two or three times each week, one can note the results of the orthostatic test, and once a week, the index of training according to the formula above.

More exactly, training status can be determined with the help of tests. Since training in distance running is directed mainly toward the development of endurance, all the functional tests deal in one way or another with the assessment of the quality of motion.

DIRECT MEASUREMENT OF MAXIMUM OXYGEN UTILIZATION

The most exact measurement of the aerobic capacity and physical work capacity of the body is determined by the maximum oxygen utilization (VO_2 max). For direct measurement of VO_2 max, the examinee must work out on a bicycle ergometer with intensity increasing progressively right up to the limit of endurance. (The length of the workout should not be less than 8-10 min.) During the last stage of the exercise, exhaled air is collected in a special sack (Douglas), after which the content of oxygen and carbon dioxide gases is measured.

Knowing the expiratory volume per minute (EV/m), which is determined with the help of a gas meter, VO_2 max is calculated. For example, if at a given level of effort, the EV/m is 120 liters of air per minute, and the utilization of oxygen reaches 4%, then the VO_2 max = 4.8 l/m (4% x 120 l). For mass screening of runners, this elaborate method is rather impractical, and therefore the indirect calculation of VO_2 max has been widely accepted using various formulas and nomograms. They are based on the closely matched correlation between the intensity of work effort, the utilization of oxygen, and the pulse rate. According to the data of Astrand and Rodahl [91] and Andersen and co-authors [88], the accuracy of these indirect measurements of VO_2 max is ± 10% when compared to direct measurement.

Table 19. Diary of Self-management. (Adopted by our club) A four-week cycle of preparation for the Pushkin Run, Leningrad, 22 September, 1985.

Month		August							September				
Days of the month		25	26	27	28	29	30	31	1	2	3	4	5
Name of training route		Vitebsky Freeway			Park				Canyon				
Fatigue					—					—			
Distance in Kilometers		25	—	5	12	—	8	—	20	—	5	12	—
Time in hours, minutes		2:20		30	1:05		50		1:50			1:05	
Work. capacity		●			●		■		■			●	
Pulse rate for 10 seconds	Recumbent (lying down)	7			7		7					7	
	Standing	9			9		8					9	
	Immediately after run	26			24		22		24			26	
	Ten minutes after run	16			15		12		15			16	
Sleep		▲ ●		●	■		■		▲	●	●	■	
General feeling of well-being		●		●	■		●		■	●	●	●	
Weight in kilograms		64							64				

Meaning of symbols: ● — outstanding, ■ — good, ▲ — bad

BEST COPY AVAILABLE

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Vitebsky Freeway					Canyon			Park						Pushkin Run-Leningrad
			—						—							+
8	—	27	—	5	12	—	8	—	18	—	5	10	—	6	—	30
		2:35			1:10		50		1:45			60		36		2:48
		■			■		■		■			■		■		●
		7 8 26 16			7 9 24 15				24 14		7 8 20 12			7 8 20 12		7 26 16
■		▲	●	●	▲	●	■	■	●		●	■	■	▲	▲	▲
●		●	●	●	■	■	■	●	●		●	●	●	●	■	●
		64							64							64

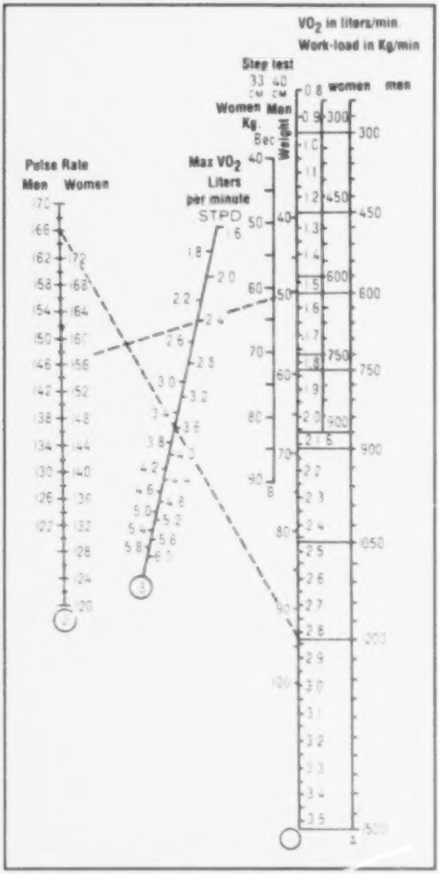

VO2 in liters/min.
Work-load in Kg/min
Step test
33 CM
40 CM
women
men
Women Kg.
Men
Bec
Weight
Pulse Rate
Men
Women
Max VO2
Liters
per minute
STPD

Figure 16. Nomogram of Astrand-Riming for determining maximum VO_2 on the principle of a submaximal test on the bicycle ergometer.

INDIRECT MEASUREMENT OF VO_2 USING NOMOGRAM OF ASTRAND-RIMING

On the bicycle ergometer, the subject performs a work load progressively increasing to the level corresponding to 75% (for example) of maximum VO_2. This level of workload is determined by the pulse rate (table 13). According to the recommendation of the World Health Organization (*WHO Chronicles*, 1971, Vol. 25, No. 8, p. 384) the first level of effort for healthy women should be 150 kgm/min progressively increasing by 100% of the initial level. (For example, 150-300-450-600 kgm/min.) For healthy men, the intensity of each level is twice that of the women (300-600-900-1200 kgm/min).

The duration of each step is 5 minutes (till achieving a steady state). The interval between the levels is three minutes. The test is stopped upon reaching a heart rate corresponding to 75% of the age-adjusted maximum VO_2.

Knowing the work output achieved and the pulse rate, a presumptive level of maximum VO_2 can be calculated from the nomogram (figure 16). For instance, one woman, upon achieving the third level of work output, equal to 600 kgm/min, achieved a pulse rate of 156/min. By using the nomogram, we find that at this work output oxygen utilization was 1.5 liters/min. A straight line joining this number with the point corresponding to a pulse rate of 156 will intersect with the "max VO_2 line" and indicate the maximum aerobic output. In our example, according to the nomogram, the maximum VO_2 is 2.4 liters/minute.

DETERMINATION OF WORK TOLERANCE

To determine physical work capacity, the body's functional condition, for middle aged persons, it is not necessary to calculate maximum VO_2. In order to find the correct workout intensity for fitness running, it is sufficient to know a person's tolerance for work, which is defined as the workload corresponding to 75% of maximum oxygen consumption. So, in the previous example with the woman, a pulse rate corresponding to 75% of VO_2 is noted to occur at a workload of 600 kgm/minute. This means that the tolerance of the body for such a work output is nice and high, and it can be carried out without overtaxing the functions of circulation and respiration.

In testing people with diseases of the cardiovascular system, complications can arise well before a work output of 75% of VO_2 has been reached. In such cases, work tolerance can be determined based on that work load at which it was necessary to stop the test (for example, due to chest pain, electrocardiographic signs of myocardial hypoxia, etc.). A work load determined in this way is called a "threshold work load."

PWC_{170} TEST

The PWC_{170} test also appears to be quite informative—measuring physical work capacity at a pulse rate of 170/minute. The greater the amount of the work output at this pulse rate, the higher is the work capacity rating. This test does not require the subject to exert a maximal or submaximal effort. The subject is given two relatively small tasks on the bicycle ergometer lasting 5 minutes each and separated by a three minute rest (for example, 300 and 600 kgm/min for women and 600 and 900 kgm/min for men).

Physical work capacity (PWC) is calculated using the formula of V. L. Karpman [35]:

$$PWC_{170} = N_1 + (N_2 - N_1) / \frac{(170 - f_1)}{(f_2 - f_1)}$$

where N_1 is the intensity of the first effort, N_2 is the intensity of the second effort, f_1 is the pulse rate at the end of the first effort, and f_2 is the pulse rate at the end of the second effort. Using the data of this test, according to the formula of Karpman, we can accurately calculate the level of maximum VO_2 (in ml) for nonathletes:

$$\text{Maximum } VO_2 = 1.7\ PWC_{170} + 1240.$$

DETERMINATION OF PHYSICAL FITNESS USING THE TEST OF COOPER

Since the test PWC_{170} requires availability of a bicycle ergometer, which is not always available, we compared PWC_{170} values with the data of the 1.5 mile test of Cooper and found a high degree of correlation between the two methods ($r = 0.98$). That allowed us to calculate a linear equation of regression:

$$PWC_{170} = (33.6 - 1.3\ T_c) \pm 1.96$$

where PWC is measured in kg/min/kg, and T_c , the Cooper test, in decimal expression of minutes (for example, 18 minutes 30 seconds = 18.5 minutes).

Since the Cooper test does not demand any special paraphernalia and is easy to conduct in nearly any training conditions, it has been successfully used to determine the training level of amateur fitness runners. The recent research of Dorosiak and Nelson [144] has also shown a high degree of correlation between the level of maximum VO_2 and the results of the 2,400 meter (1.5 mile) run. However, one should never carry out this test sooner than 6 months after the beginning of an exercise program, so the stress of the run will not be too dangerous.

A "LESSON AFTER THE BELL"

So we know now how to plan a training effort and determine its size after familiarizing ourselves with the principles of training. Now it is time to begin the workouts! But how do we organize them, and in what sequence do we proceed with the running exercises? Indeed, running is a powerful influence on the body and, if not used skillfully, can cause irreversible harm.

The basic form of organization of the exercises, so to speak, a link in the long chain in the training process, is the training lesson in which one gains not only knowledge but also useful habits of motion and "teaches" the body to deal with various stresses.

The structure of the training lesson is determined by certain physiologic, educational, and psychological principles and consists of three parts: the preparatory part ("warm up"), the "main" part, and the concluding part ("warm down").

The first part is the preparation for the more stressful exercises of the principal part. Here, there are two objectives. The first objective is to ensure a favorable educational setting and psychologically motivate the participant. It is important to boost the runner's morale and general feeling of well-being, mood, and desire to train. Special attention must be given to individuals who have special health problems.

The second objective is to "warm-up"—that is, to stimulate the body's functions. Warm-up is a critical factor in the body's transition from the resting state to the stress of a workout. If no warm-up is carried out prior to a run, for example, a 3 or 5 km run, the heart reaches maximum efficiency only after the third or fourth minute and seems to experience an "inertia" at the start, which causes heart function to "lag behind" while the muscles are working at full capacity. And this is a disadvantage since energy is being generated mostly by anaerobic processes.

The warm-up consists of both general limbering up (stretching) and specific exercises (brisk walking or running). Slow tempo is used, and the muscles are not, as a rule, called upon for any high performance. The length of the warm-up should not be longer than 10-15 minutes. This time is completely sufficient to stretch the muscles and activate optimal breathing and circulation. Longer warm-up time can result in fatigue, especially in older persons.

Warm-up begins with walking and breathing exercises. Then follow a few general exercises for the muscles of the legs, arms, and spine (bending, twisting, etc.). The warm-up concludes with special exercises for the feet and the joints of the ankle: Walking on the heels, the tip-toes and the inner and outer surfaces of the foot, rotary motion of the ankle joints, and rising on the toes. People of middle or more advanced age should not use such special exercises as running with hyperflexed legs, high knee lifts, etc. These exercises are considerably more strenuous than light running and cause rapid fatigue and increase in the pulse rate.

BEST COPY AVAILABLE

Persons with high blood pressure should exclude all strenuous exercises requiring breath-holding or excessive exertion (for example, sit-ups), deep bending, twisting of the trunk, or jumping. At the end of the warm-up there should be two short easy laps and exercises to re-establish breathing. After this, a pulse count is taken and should not exceed 120. After the warm-up comes a rest of 3-5 minutes, and then begins the main part of the work-out.

One should also know how to finish a training session. In the concluding part of the exercise, it is recommended that the work load be reduced by gradually slowing down the tempo to a walking pace. It is also useful to go through a series of deep respiratory movements (inhale, exhale) and decrease any remaining tension, to reduce muscle fatigue.

This simple technique allows the body to resume a normal condition and creates a pleasant feeling after the session.

Chapter Four
RUNNING AND MEDICINE

"Running for the healthy. Medicine for the sick!" In our times, this is the prevailing belief of many practitioners of medicine. However, the enormous experience of the past two decades indicates that slow running can be an effective modality in the battle against certain diseases.

Although there is no doubt that slow running is useful for the purpose of preventing disease and enhancing the functional capabilities of the body or physical fitness, still the therapeutic or "curative" use of this means is a much more complicated matter. In this connection, since the physician or coach is able to vary the amount and intensity of the workout load over a wide range in groups of health walkers or runners, absolute contraindications to exercise are quite limited. We have summarized the basic data of the leading specialists in the area of sports medicine and have established the following list of basic contraindications for endurance training [45, 47, 52, 80, 120, 138, 190]:

1. Heart disease: both congenital and acquired, with mitral stenosis (narrowing of the mitral valve)
2. Presence of abnormal heart rhythm (flutter, etc.)
3. Circulatory insufficiency or respiratory insufficiency of any etiology.
4. High blood pressure (200/110 and higher) resistant to anti-hypertensive therapy (or progressive hypertensive disease with frequent crises)
5. Chronic renal disease, thyrotoxicosis, or severe forms of sugar diabetes.
6. Glaucoma and progressive near-sightedness, threatening retinal detachment.
7. Thrombophlebitis of the lower extremities.

Certainly, one should never run during any acute illness, including "colds," or during a flare-up of any chronic illness. A few cases of death have been reported in patients with acute myocarditis who tried to treat their "colds" by running [266]. Therefore, in minor illnesses, regardless of their cause, one should stop one's training program and wait until all symptoms of illness disappear. Upon resuming workouts, one should cut the usual workout load to half and then gradually increase back to the usual level. This principle should be observed by all fitness runners.

Coronary artery disease, diseases of the vessels of the lower extremities, liver, and bile ducts, and many others provoke lively discussions regarding participation in distance running. But even if there were exact data in this area of medicine, the question of whether to participate in exercise is always an individual matter, because for any given diagnosis, the degree of expression and form of the disease is different for each individual. Thus out of ten hypertensive patients in stage II, half may well be admitted to an exercise program, while the other half must be categorically excluded. Permission is given by the treating physician, who is well acquainted with all the facets of the patient's illness, together with the sports-medicine specialist.

All beginning runners over 30 years of age should undergo a thorough medical examination, including a stress test (a two-minute run-in-place or workout on the bycycle ergometer) with an EKG tracing before and immediately after the test.

RUNNING AND CARDIOVASCULAR DISEASE

Since the process of running puts a stress principally on the cardiovascular system, problems are likely to arise in persons with cardiovascular disease. Is it necessary to place an additional stress on organs that are already functioning imperfectly? Will it be useful? and is the risk worth it? Certainly the question of fitness running in cardiovascular disease is far from resolved. In fact, it is being studied intensively in many countries, and both fast walking and jogging are being used more and more widely to normalize the function of the cardiovascular system and to recover functions lost due to many different diseases.

Patients with neurocirculatory dystonia (NCD)* do not have structural or morphological damage of any vital organs, but they do have reversible functional changes caused by disorders in the neuroregulatory functions of the cardiovascular system. This is why distance running is widely used as a health measure and healing remedy [89]. Depending on the prevalence of sympathetic versus parasympathetic influence of the nervous system and a person's blood pressure, three types of NCD are identified:

HYPERTENSIVE—where sympathetic influences predominate (rapid pulse and high blood pressure)

---

*Translator's note: There is no equivalent or counterpart of this diagnosis in "western" medical science. It appears that Russian (and Soviet) medical science and medical thinking has identified and "diagnosed" this condition called "neurocirculatory dystonia" as a means of studying and learning to correct a number of seemingly connected conditions. In western medical terminology, these conditions are categorized and diagnosed separately and differently. To better understand what the authors are discussing (NCD) we could roughly translate the condition into the plain and simple English phrase "being out of shape" or the "couch potato syndrome."

HYPOTENSIVE—where the prevailing influence is vagal (parasympathetic) with slow pulse and low or normal blood pressure; and

COMBINED—where there are both vagal and sympathetic disorders in the regulation of body functions (unstable pulse, fluctuations in blood pressure, headaches, and angina [pains in the heart area]).

Patients with NCD of the hypotensive type have the most to gain from fitness running, since their capacity for physical work really doesn't differ much from that of healthy people. The lowest tolerance for exercise loads is found in those patients with NCD of the hypertensive type, whose tolerance for exercise is 50 to 100% lower than persons of the hypotensive type. During exercise testing or treadmill studies, the abnormal EKG changes characteristic of patients with coronary disease (depression of the ST segment, flattening of the T wave) either fail to worsen or disappear altogether as a person gradually increases his/her exercise load. By contrast, persons with severe ischemic heart disease react quickly to the increasing stress of the treadmill study with signs of myocardial ischemia appearing on the EKG. These facts are thought to be confirmation of the positive influence that physical training has on NCD patients [1,12, 48, 57].

L.V. Krugliak and I.V. Roy [38] conducted studies using fitness walking in 130 NCD patients with speeds increasing from 4 to 6 km/hr. The results of the study showed considerable improvement in the electrocardiograms of these persons as well as improvement in their tolerance for exertion and a decrease or total disappearance of arrhythmias. These changes are explained by an increase in the "tone" of the sympathetic nervous system under the influence of training, as well as a decrease in the arrhythmia causing influence of the vagus nerve [221]. During fitness running in hypertensive patients in the 30-60 age group, G.N. Smoliakova [60] observed a drop in blood pressure as well as disappearance of arrhythmias and an increase in the heart's stroke volume—which indicates significant hemodynamic improvement and normalization.

However, exercise programs for patients with dystonia, especially those with an inclination to high blood pressure, require a certain caution. One must always keep in mind that they are very sensitive to the effects of moderate and even mild training stress, and very prone to fatigue. As a rule they should begin with a prolonged period of fitness walking, with very slow and gradual increases in their exercise load. This will demand firmness and patience from both patient and coach. Attempts to accelerate the process of adaptation to exercise loads usually result in failure and can cause exacerbation of the disease—not to mention ruining the whole exercise program!

In our study we observed 58 NCD patients between ages 25 and 60 who engaged in fitness walking. After several years of exercising, the condition of all of them improved considerably. Headaches disappeared, blood pressure normalized, and working capacity increased.

Patient A.B., aged 40, was active in the exercise club for five years. Before doing fitness exercise he suffered from frequent headaches and substernal pains, unstable blood pressure, weakness, fatigue, and insomnia. His clinical diagnoses were neuraesthenia, NCD of the hypertensive type, rheumatism in remission, and mitral incompetence. His exercise program began with dosed walking for 1,600 meters at a pulse of 120 per minute. During the first month, the distance was increased to 2,000 meters; during the second month to 2,400 meters; and thereafter it was not changed for a long time. The speed of the walking remained constant at about 5 km/hr.

In spite of such an easy training regimen, the exercises were often interrupted because of the appearance of substernal pains and vertigo. By the end of the first year, the distance was gradually increased up to 3,200 meters, after which short distances of running were allowed. The heart rate (pulse) did not exceed 132/min. A year later, the regimen was increased further and uninterrupted running was allowed. At this point, the distance was increased to 5 km. By the end of the third year, he was able to run 7 km in 45 minutes with the same pulse regimen. All of his complaints had disappeared and blood pressure had normalized, but small nonsignificant changes remained on the EKG.

Slow running as a healing remedy is most beneficial for patients in the beginning stages of hypertensive disease, because rhythmic exercise of moderate intensity has been shown to result in widening of the vascular lumen in working muscle groups and a decrease in peripheral resistance more than four times. As a result of these changes, blood pressure lowers [17, 247, 278, 306, 335]. A decrease in systolic as well as diastolic pressure is noted in hypertensive patients under the influence of endurance training [104, 115, 120, 174, 251, 289, 298, 339, et al.].

In the setting of a cardiology health resort [70, 74] an improvement in functional abilities and a drop in blood pressure are noted even after a four week course of training using walking and running. Cooper [122] describes an interesting experiment in which 105 hypertensive patients took part. While one group received treatment in the form of medication, jogging was used in a second group. At the end of the experiment, the diastolic pressure of the first group of patients decreased by 20 mm while the decrease in the second group was 15 mm. Many scientists share Cooper's opinion that if the blood pressure is not more than 150/90, then a running program alone can be quite effective without medication.

In the case of mild hypertension (diastolic pressure below 100) treatment can consist of nondrug therapy using endurance training and a reasonable diet [205]. In the case of more severe hypertension, a combined treatment will be necessary, using an antihypertensive drug (such as a beta blocker) as well as an exercise program. The only absolute contraindications to physical exercise or training would be either a case of hypertension greater than 180/100 that cannot be controlled by medications or rapid progression of the disease with frequent hypertensive crises. Endurance training in any form is also contraindicated in the third stage of hypertension, where irreversible damage to vital organs has occurred.

One should bear in mind that even when blood pressure is normal in the resting state, it can sometimes rise precipitously under a physical stress. This is why stress testing is obligatory for all hypertensive patients irrespective of their blood pressure reading. If, after a standard stress, the pressure rises up to 250 or more, it means that training is out of the question. In such a case, it is necessary first to lower the pressure with the help of medication.

The benefits of physical training do not end with an improvement in cardiovascular tone and a reduction in blood pressure. A training program also gives indirect therapeutic benefits: It increases the removal of salts through perspiration, decreases excess body weight, and normalizes nervous processes in the cortex of the brain [294].

It is important to choose a suitable type of physical exercise. For persons suffering from hypertension, rapid walking or jogging are the most acceptable. The secret of success is in an individual dosing of the exercise load based on the severity of hypertension and how the patient and his/her blood pressure readings respond to exercise. The higher the blood pressure, the more strict control must be maintained over the patient's execution of the training program. Don't forget that the NCD patients may have a reduction in their tolerance to exercise and, for this reason, the "dose" of walking or running must be minimal at first. As a result of testing more than 200 patients with hypertension, it was discovered that, in the first stage of the disease, the physical working capacity averages 600 kg/min, while in the second and third stage, exercise capacity falls to an average of 350 and 320 kg/min respectively [67]. Because of this, training must begin with small doses of walking at a pulse rate of 110-120 beats/min. If exercises are to be carried out along with doses of antihypertensive medication, then one should take particular care in prescribing the doses of exercise, as rhythmic exercises can augment the effects of the drugs and lead to a sharp drop in blood pressure [163].

In our study, we observed 46 patients with first and second stage hypertension, with blood pressures in the range of 160/95 up to 180/110, who participated in fitness walking and running. As a rule, after training, the systolic pressure decreased by 10-40 mm and the diastolic by 5-10 mm.

As an example, N.K., a lady of 40 years, after a program of walking at 6 km/hr for 2,400 meters, consistently reduced her blood pressure from 180/110 to 140/85. Her pressure later normalized. In fact, all subjects who continued regular training experienced stabilization of their blood pressures at levels close to normal.

However, five persons discontinued their training early because a reduction in blood pressure was not noticed in their cases. Many specialists [7, 294] explain this phenomenon by peculiarities in the body's circulatory regulation. By following a program of rhythmic exercise, patients with the vascular type of autoregulation (where blood pressure is maintained by high resistance in the peripheral vessels) and the intermediate type of autoregulation (where blood pressure is maintained by both blood vessel resistance and cardiac output) changed their "style" of autoregulation to the cardiac type as a result of an increase in stroke volume and dilation of peripheral vessels. Their training was accompanied by a decrease in blood pressure. The training of patients with the cardiac type of autoregulation could not be effective, however, as it increased the the cardiac output that was high even before the exercise program but it did not improve the extremely low vascular tone.

Prolonged hypodynamia (too little physical activity) is conducive to the vascular type of regulation, because it results in a decrease in myocardial contractility and an increase in vascular tone. This mechanism of circulatory autoregulation is the most dangerous because it tends to lead to hypertensive cardiovascular disease. By contrast, regular endurance training directly opposes the hypodynamia and induces the cardiac type of regulation, which, in turn, diminishes the risk of hypertensive disease. R.E. Motylyanskaya did a study of the runners who trained at the Lenin Central Stadium in Luzhniki and found that 75% of them manifested the cardiac type of circulatory autoregulation [52].

In addition to the use of rhythmic exercise, numerous other measures are important in the total treatment of hypertension (high blood pressure). Such measures include proper lifestyle and diet, proper balance between work and recreation, avoidance of smoking, getting proper sleep, autosuggestion training (similar to biofeedback), avoidance of extra weight, and the limiting of salt, fat, and animal protein in the diet. Successful treatment of high blood pressure can occur only if all of these methods and modalities are applied.

For patients with ischemic heart disease (coronary disease), running can present a real danger, as sclerosing vessels have no ability to dilate so as to increase the coronary blood flow and satisfy the increased oxygen need of the heart muscle.

CAN RUNNING HELP IN THE BATTLE AGAINST CORONARY INSUFFICIENCY?

- "RUNNING FROM INFARCTION"—Proponents of fitness running subscribe to this motto with optimism.
- "RUNNING TOWARD INFARCTION"—More skeptical medical authorities respond with this motto.

Who is right, the theorists, or the practitioners? The running enthusiasts, who consider running a panacea for all diseases, or the scientists who recognize only statistics?

It is considered, theoretically, that running is contraindicated for coronary patients who have frequent anginal attacks or who demonstrate coronary insufficiency on a stress test (more than 2 mm of depression of the ST segment on the EKG). If the ST segment depression is less than 2 mm, then it is allowable to proceed with an exercise program [337]. In actual practice, however, there are very few physicians, even among cardiologists, who seem to have the courage to allow (much less to advise) a running program for a patient with coronary disease.

Nevertheless, intensive exercise, including fast walking and jogging, is being more and more widely used in many countries of the world. The first mention of treating coronary artery disease by means of physical exercise goes back to the 18th century. In 1772, Heberden wrote about a man who got rid of heart pain by sawing firewood every day [164]. Widespread use of physical exercise by coronary patients, with the aim of preventing both initial and repeat infarctions (heart attacks), started in the middle sixties of our own century [116, 170, 206, 230, 246, et al.]. A series of animal experiments served as the scientific impetus by showing the positive influence of physical exericse on cardiac activity following myocardial infarction. Dogs with an experimental infarction (ligation of the descending coronary artery), at the end of a six week course of compulsive daily training on a treadmill for 30 minutes at a speed of 6.5 km/hr, had significant improvement in the heart's circulation when compared with a control group of animals. Their hearts worked not only more effectively, but also more efficiently [150]. It was also discovered that endurance training improves the contractile properties of the heart muscle and improves its ability to withstand an oxygen scarcity—by reason of more economic energy consumption [304].

In animal studies with experimental atherosclerosis, it was found that prolonged endurance training of only moderate intensity was remarkably successful in suppressing the atherosclerotic process. Extensive atherosclerosis of the aorta was caused in apes by means of an atherogenic diet containing large amounts of cholesterol, after which half of the animals ran on a treadmill for an hour three times a week. Six months later, almost complete disappearance of the atherosclerosis was observed in the trained animals, while the atherosclerotic deposits continued to grow in the control group.

Complete disappearance of aortic atherosclerosis was also noted in dogs trained on a treadmill for one hour a day. However, this effect is achieved only by training of sufficient length and intensity [303, 320].

Long-term observations of coronary patients led many researchers to believe that rhythmic endurance training can be effective in halting the progress of atherosclerosis in humans as well [308]. The possibility of reversing the atherosclerotic process in coronary patients is due to more active lipid metabolism, a decrease in atherogenic (LDL) cholesterol, and an increase in HDL, which is able to "seize" and remove cholesterol molecules from the vascular walls [288].

In a group of 100 coronary patients, after six months of walking and running, blood cholesterol decreased an average of 20%, and triglycerides decreased an average of 24% [11]. Covan [132] observed an increase of HDL levels in 40 coronary patients after a three week course of physical rehabilitation that included running (20-40 minutes) three times a week on a treadmill. N.D. Gogokhia and co-authors [22] also reported a normalization of cholesterol metabolism in coronary patients, with an increase in HDL, after 12 months of a rehabilitation program involving use of an exercise bicycle for one hour, three times a week. Especially noteworthy was the dramatic drop in the atherogenic triglyceride levels (table 20).

	Serum Cholesterol mg.%	Triglycerides mg. %	HDL mg. %
Baseline data	252	224	41.6
After 12 months	244	169	46.2

Table 20. Dynamics of lipid metabolism in patients with coronary artery disease following 12 months of physical training: from N.D. Gogokhia, 1980 [22].

The normalization of fat metabolism is explained by the activation of the enzyme, lipoprotein lipase, and the stimulation of lypolysis (splitting of fats) [228]. Under the influence of endurance training, the fibrinolytic activity of plasma increases and blood viscosity decreases, which makes the heart's work easier and decreases the danger of thrombus formation and development of myocardial infarction [338].

DOES MYOCARDIAL BLOOD FLOW INCREASE UNDER THE INFLUENCE OF RHYTHMIC EXERCISE?

This question has not yet been answered conclusively. Numerous studies with animals have shown that training on a treadmill leads to a considerable increase in blood flow through the heart muscle by reason of formation of new capillaries [118, 137, 219, 223, 304, 323].

People with coronary insufficiency have difficulty with the development of collaterals. Coronary angiography (an x-ray movie taken of the heart after injection of a contrast substance into the coronary arteries) [256] failed to show any changes in the coronary blood flow of coronary patients after physical training in many cases. The negative results of these angiography studies may be explained by an insufficient sensitivity of this method of research, as new capillaries less than 0.1 mm in diameter are not detected by x-rays [33]. But even using this method, Ferguson succeeded in demonstrating development of collateral circulation after a 12 month course of training in 2 out of 14 cases of coronary artery disease.

By means of a more sensitive newer method, using radioactive isotopes (Thallium^{201}), an improvement in myocardial perfusion has already been demonstrated in 6 of 16 cases of coronary disease among patients who completed a course of endurance training [259]. Such research tends to confirm the older animal data that indicate the positive influence of physical training on myocardial circulation. Therefore, if not for all patients, at least it can be said for some patients with damaged coronary arteries, that rhythmic exercises can bring real help. Physical training considerably improves the general state of coronary patients in addition to directly influencing the atherosclerotic process and improving the blood supply to the heart muscle. Most such patients demonstrate a general functional improvement in their cardiovascular system as a result of dedicated fitness running.

Many Soviet and foreign specialists [8, 116, 155, 284, 307] have observed an improvement in the functional status of coronary patients under the influence of training. This improvement is expressed by a decrease in blood pressure and resting heart rate as well as an increase in working capacity [44, 75, 80].

One group of 96 coronary patients carried out a four week training program of walking and running. Following the program, their average blood pressure decreased from 160/92 to 146/88, and their maximum work output increased by 20% compared with baseline levels. S. P. Zhukovsky observed a group of men ages 30-70 for a period of three years at the Riga amateur running club, "Daugava," and recorded some interesting facts. During a thorough medical examination at the beginning of the study, coronary arteriosclerosis and occasional anginal attacks were a problem for most of them, with three of them having already suffered heart attacks. EKG telemetry was used to monitor these runners during their actual workouts, and this method was useful in uncovering various EKG abnormalities in 20 of the 30 runners. After six months of regular training, a follow-up examination revealed that such pathological changes during running were found in only three cases. In the remainder, the EKG totally normalized.

Zhukovsky gives an interesting example of the benefit of fitness running in an elderly person. During the clinical examination of 72 year old patient D., the following diagnosis was made: coronary arteriosclerosis with a narrow stenosis and stage II hypertension. He had frequently received treatment before this study and often took nitroglycerine to relieve chest pains. In 1970, he had begun a program of fitness walking on his own and then subsequently advanced to jogging, working his distance of continuous running up to 5 or 6 kilometers. Within three years of regular exercises, his blood pressure totally normalized and the symptoms of coronary disease disappeared. However, only healthy people should begin such a running program on their own. Patients should strictly observe all of their doctor's and coach's advice, especially in the beginning stages.

Twenty-two patients with varying degrees of coronary artery disease took up fitness walking and running under our supervision. The majority were periodically troubled with pains in the heart area, but did not require an "extra dose" of vasodilating medicine. The usual EKG changes diagnostic of myocardial ischemia (depression of the ST segment, depression of the T wave, etc.) were found in all of these patients. Two persons had changes indicating diffuse myocardial disease. In the process of their training, all of them noted improvement in their general health and a decrease or total disappearance of the discomfort in the heart area. However, the positive changes in the EKG developed considerably more slowly than the improvement in the general state of our patients.

Unstable angina (frequent attacks of chest pain requiring immediate medical intervention) and pronounced coronary insufficiency based on EKG changes in the resting state or with minimal exertion (less than 600 kg/min) are considered by us to be contraindications to fitness running for coronary patients. However, for patients with coronary insufficiency without acute symptoms, endurance training can be highly effective.

Fifty year old patient V.I. began training in a beginners group one month following an attack of acute angina (heart pain) indicating a heart problem. He had been experiencing chest pains, unstable blood pressure, poor sleep, and fatigue. The clinical diagnosis was the following: arteriosclerosis of the coronaries, ischemic heart disease, and stage I-II hypertension. On his EKG, subtle signs of poor oxygen supply to the heart muscle were seen, with pointed T waves in the chest leads. His exercise tolerance on the treadmill was unsatisfactory. At first, a program of dosed walking for a distance of 1,600 meters (four laps of the stadium track) at a speed of 120 pulse beats per minute was prescribed for him.

In three months, his walking distance was gradually increased to 3,200 meters, and six months later, to 6400 meters. After that, short distances of running were allowed. By the end of the first year of training, running was still alternated with walking and during his training, the heart rate did not exceed 120. Within this time, the runner's condition considerably improved: his heart pains almost never occurred; his sleep and general well-being improved; his blood pressure dropped; and his capacity for work greatly increased. However, full normalization of his EKG came only after two years of regular training, and by this time, on Sundays, our patient was easily running 10 kilometers in 60 minutes. In this stage of training, his pulse rate reached 144, and his anginal pains had ceased.

Running may be temporarily prohibited for some patients with cardiovascular diseases. But after proper treatment and an extensive course of fitness walking, these patients can also begin running. It is never necessary to be in a hurry.

IS IT POSSIBLE TO RUN FOLLOWING A HEART ATTACK?

Over the last two decades, clinical opinion on this matter has greatly changed. Although the first commandment in the past was strict inactivity and prolonged rest, now the matter is different. The treatment of a postinfarction patient in a modern cardiology clinic can't be imagined without the use of physical exercise almost from the first days of the "heart attack." The ingredients for total recovery of the body following a heart attack are complex and include medical factors as well as physical, psychological, professional, and socioeconomic rehabilitation [78].

Medical rehabilitation requires continuous observation of the patient during the early critical period, with control and correction of the body's functions with the help of medications.

The goal of physical rehabilitation is to achieve the recovery of the heart muscle and its return to its former capacity for work, even though it has now suffered necrosis (tissue death) of the injured portion of heart muscle that subsequently "heals in" with scar tissue. "Detraining" is an additional factor, which weakens the heart muscle's contractile (pumping) function and weakens tolerance for exertion. "Detraining" results from forced inactivity in the presence of compromised coronary arteries [183]. Due to these factors, the functional ability of the myocardium can be decreased by 12 to 28% [313].

Nowadays, physical rehabilitation has become a decisive factor in the total picture of cardiac rehabilitation [78, 83, 143, et al.]. One cannot overestimate the positive influence of exercise on a postinfarction patient's psychological well-being [313]. Many "victims" of the coronary epidemic can return to a normal life and even begin a running program with the help of regular physical training, but at first they should follow a three stage protocol of physical rehabilitation:

STAGE I —"Hospitalization" is carried out in the hospital and is 4-6 weeks in duration.

STAGE II—"Recovery" or "convalescence" is 1-3 months and is carried out in the setting of a specialized cardiology sanitorium, a rehabilitation medical center or a local medical center.

STAGE III—"Supportive" stage endures for the patient's entire lifetime.

During Stage I, the hospital stage of the rehabilitation, early ambulation as well as specialized structured exercises are carried out for 10-15 minutes once or twice daily, depending on the state of the patient [58]. Serious complications in the early postinfarction period—acute pulmonary edema, cardiogenic shock, serious disorders of cardiac rhythm, or angina at rest—are all contraindications to exercise during this first stage of rehabilitation [21].

Before release from the hospital, the patient receives his/her first "stress test" on a bicycle ergometer, to assess the appropriateness of a training program during the second stage. A gradually increasing exercise load is used beginning at 150 kg/min and gradually increasing by 100% as the patient proceeds through the subsequent stages of the test. The duration of each stage is 5 minutes with a rest of 5-10 minutes between the stages. The number of stages in one test is never more than four. The maximum allowed stress is never more than 75% of the patient's age-adjusted maximum heart rate (70% of VO_2) [34].

Tolerance for stress or "threshold for stress" is determined by the workload at which the heart rate reaches 75% of the predicted maximum or by the stress level at which symptoms occur which force the test to be stopped. These are: chest pain, severe shortness of breath, or obvious EKG abnormalities (depression of the ST segment more than 2mm, ventricular arrhythmias, etc.). These symptoms arise as a result of a sharp discrepancy between the increasing oxygen demand of the heart muscle and the limited ability of its sclerosed coronary vessels to increase the coronary blood flow. It is considered that this level of stress corresponds to the limit or threshold of anaerobic metabolism [81].

If the tolerance for stress is less than 300 kg/min, then physical training is contraindicated during Stage II of rehabilitation. The test performance is felt to be successful if the patient can proceed through the four stages of work without a heart rate elevation above 120/min and without chest pains or signs of myocardial oxygen starvation on EKG.

Stage II of rehabilitation is carried out in cardiology sanitoriums or in local medical rehabilitation centers. In the cardiology sanitorium, a complex program of physical training is used: gymnastic exercises in a gym for 10-20 minutes; cross-country walking with a beginning distance of 1,500 meters; and training on an exercise bicycle three times a week for 30 minutes with a pulse of not greater than 120-130 per minute [58]. At the end of Stage II, the second stress test must be done. If exercise tolerance is less than 450 kg/min, then the training of the third stage is contraindicated.

Stage III can be carried out in an outpatient clinic or in special groups at the clubs of fitness walkers and runners where experienced coaches and medical personnel work. The main focus of this stage is endurance training. Depending on the patient's state, it begins three to six months following a heart attack [143 et al.].

All of the programs in Stage III can be divided into three main groups:

1. Controlled workouts in a laboratory setting on a bicycle ergometer or a treadmill.
2. Fast walking or slow running in the form of partially controlled or independent exercise.
3. Complex programs of physical exercise all the way up to participation in competitions (gymnastics, running, sporting events, etc.).

Rehabilitation programs of Stages II or III, including rhythmic exercises for endurance, unlike the minor calisthenics of the first stage, have received abroad the name of "intensive physical training," or simply "physical training." We will also use this term.

During the early stages of rehabilitation (up to one year), a strictly controlled program in laboratory conditions, using an exercise bike or walking or running on a treadmill, under the control of medical personnel, is the safest for patients after an infarction [143].

At the beginning of Stage III, while the capacity for work is still low, a gradually increasing stress load on a bicycle ergometer is used beginning at 150 kg/min and progressing to submaximal (threshold) stress levels with intervals of 3-5 minutes of rest between the stages. After several months of training, when exercise tolerance has increased and work will not cause rapid fatigue, nonstop pedalling at subliminal level is used for 30 minutes 3-5 times a week. (Subliminal means that the work load is a little lower than threshold [116].) Also, training in the form of walking or running on a treadmill can be used, and the running circuits and trails also allow us to dose exactly the amount of work prescribed. As the speed of movement along the running path gradually increases from 4 to 10 km/hr, fast walking imperceptibly transforms itself into slow running [206].

As fitness improves and the functional state of the patient improves, the training under the control of the medical staff is transferred into a partially controlled program. For example, once a week training could be carried out under the observation of medical personnel, and twice a week the patients could exercise by themselves with an assigned heart rate [133]. In 1977, in the United States, a partially controlled program of rehabilitation was developed providing for one session a week in a cardiology center under the supervision of a physician and two independent sessions at home each week according to an individualized plan, taking into account the individual patient's tolerance for exercise [262]. Controlled training sessions include dosed walking and running on a treadmill and a workout on an exercise bicycle or rowing machine. Independent exercises include fast walking and walking alternating with running. The intensity of the workouts should approximate 70-85% of the threshold heart rate as determined by the submaximal test on the treadmill. The duration is 20-30 minutes.

A program of partially controlled training sessions is carried out for 12 weeks, after which the patients proceed to independent exercises, provided they have achieved a high enough exercise tolerance. For those patients with low exercise tolerance, all the sessions are carried out under the supervision of medical personnel ("controlled training"). American scientists consider this system of rehabilitation more effective and safer with respect to cardiovascular and orthopedic complications [184].

Fully controlled training sessions three times a week for 20-30 minutes are popular in the United States and Canada [140, 210, 310]. More comprehensive training programs are carried out in West Germany in the setting of specialized hospitals [112]. Japanese scientists [143] consider partially controlled programs of rehabilitation just as effective and safe.

A year after infarction, those patients with higher tolerance for exercise (more than 750 kg/min) can transfer to independent programs of walking or running. At first they should walk at a speed of 6.5 km/hr. After this, the patient is allowed to alternate walking with running for distances of 50 to 100 meters. Gradually, running becomes continuous; and the distance increases up to 3-5 kilometers [78].

Some specialists suggest intensive sports exercises be used in rehabilitation programs [182]. In a rehabilitation center supervised by Gottheiner, more than 3,000 coronary patients, 540 of whom had had a myocardial infarction, trained over ten years. The training included fast walking, running, bicycle riding, rowing, and volleyball. The sessions were carried out three times a week for 30-60 minutes. At the end of the course of rehabilitation, competitions in cross country on a hilly course for 11 km were held. The participants covered the distance in 60-80 minutes.

Notwithstanding the positive experience of this medical center, participation in competition by patients who have had heart attacks is hardly worthwhile. Programs of physical exercise in cardiology clinics differ a little depending on experience and traditions. Thus, according to the statistics of the 45 largest medical centers of the world [213], various types of physical exercises for post-heart-attack patients are used at the following rate:

Therapeutic physical training:	73%
Controlled training sessions of fast walking:	48%
Controlled training sessions of running:	31%
Independent fitness running pursued by patients, on their own:	41%

The main question of all rehabilitation programs is the intensity of the workout load involved in training. There can be several approaches to this problem.

1. The stress or "exercise load" is dosed in percent of maximum heart rate, using VO_2 max as 100% [175, 216, 292]. The rehabilitation council of the International Society of Cardiologists [34] recommends limiting group training of post-heart-attack patients to a pulse rate of 60-70% of maximum. Baum [100] recommends defining the optimal intensity of work with the following formula:

(170 minus the patient's age)

The main shortcoming of these recommendations is that they don't take into consideration individual patients' tolerances to stress, because the limit of endurance in many cases is considerably lower than the calculated levels.

2. The workload should be brought up to the threshold level, since this will cause myocardial ischemia, which is a stimulus to development of vascular

collaterals in the heart muscle [165, 265, 348]. Using this model, the intensity of the work (the speed of walking or running) is increased up to the point where pain appears.

3. Another approach which appears more valid and, most importantly, safer, prescribes the intensity of the workout at a level just below the individual's threshold as determined by a submaximal stress test. The load level of 70-85% of threshold is considered optimal [143, 177]. Amsterdam [87] recommends carrying out training sessions at a pulse rate 10 to 20 beats below the threshold level. In this model, individual tolerance is given special attention. It is extremely important to note that this parameter is NOT taken into account when dosing by percentage of VO_2.

4. Several attempts have been made to calculate the maximum acceptable level of stress with the help of various formulas based on correlations between the intensity or amount of stress and a number of individual patient-parameters [49].

$$H_{max} = 1.23 X_1 + 0.6 X_2 - 1.76 X_3$$

where H_{max} is the maximum permitted intensity of stress, X_1 is the age of the patient, X_2 is body mass in kilograms, and X_3 is mean blood pressure in millimeters Hg.

A high coefficient of correlation (0.973) between the calculated values and those obtained by direct measurement during a stress test on an exercise bicycle speaks for the practical value of this method.

EFFECTIVENESS OF REHABILITATION

The effectiveness of rehabilitation programs is judged by improvements in the various biological indices of the participants, the incidence of repeat heart attacks, and mortality statistics over the years following participation. Physical training results in considerable improvement in the functional state of the cardiovascular system: an increase in the contractile ability of the heart muscle, and an improvement in the propulsive function (pumping strength) of the left ventricle of the heart, and also a compensatory hypertrophy (enlargement) of the intact segments of the heart around the zone which has been destroyed by the heart attack [152]. This makes it possible to avoid any dangerous ectasia (dilation) of the left ventricle at the expense of stretching of the scar tissue that builds up in the heart muscle after a heart attack [30]. The increase in the functional ability of the heart muscle allows it to respond to stress and an increase in VO_2 by increasing both stroke volume and minute-blood-volume [3, 75, 95, 110, 136, 161].

According to the data of the All-Union Cardiology Center of the USSR Academy of Medical Sciences, participants in a 12 month course of rehabilitation following a heart attack experienced an increase in stroke volume (volume of blood pumped by the heart in one beat) from 70 to 80 ml and a reduction in the heart's resting pulse rate [54]. In a control group of patients, receiving only medication following their heart attacks, tests actually indicated some worsening of these same parameters.

For coronary patients, the measurement of "maximal aerobic capacity" or VO_2 (the maximum volume of oxygen that a person can use up in one minute) is one of the most important and objective indicators of health, for it indicates the condition of the two most vital systems of life maintenance, respiration and circulation [78]. Post-heart-attack patients are found to have VO_2 levels of 22-27 ml/min/kg—some 20-30% lower than healthy people [312]. In those patients who have angina post-heart-attack, the absolute values of VO_2 are found to be reduced an average of about 1.5-1.8 l/min; however, in the absence of angina, the VO_2 levels are as high as 2-2.5 l/min [296].

Compared with test results obtained at the beginning of their rehabilitation courses, post-heart-attack patients develop a distinct increase (of 16-56%) in their maximum aerobic ability as a result of their physical training [117]. Hellerstein [184] observed an increase in VO_2 from 21 to 26 after only three months of physical exercise. In the course of several years of exercising, VO_2 levels improve and increase right up to the levels found in healthy nontrained men—30 ml/min/kg [81].

Japanese scientists [143] have noted an increase in VO_2 from 27 to 31 ml/kg/min over a 12 week partially controlled rehabilitation program. Under more intensive training, this indicator can rise to 35 ml/kg/min. However, it is not always possible to determine the maximum aerobic abilities of all coronary patients, for testing may have to be discontinued because of various complications that develop early in the training. For this reason, a study is usually limited to determining a patient's threshold or tolerance for exercise.

Referring again to the study of the Soviet Cardiology Institute [3], tolerance for stress rose from 290 to 580 kg/min over a three year period in those post-heart-attack patients on an exercise program, while it actually decreased from 330 to 310 kg/min in the control group of patients during the same period of time. One study showed an increase, following a rehabilitation course in a cardiology sanatorium, of work tolerance from 420 to 600 kg/min [58]. D.M. Aronov [8] observed a similar increase in exercise tolerance from 510-720 kg/min over a two year training program.

Another important indicator of the functional state of the cardiovascular system of coronary patients is the so-called "double product" (the product of the heart rate times the systolic pressure at the peak of the workout divided by 100), which reflects indirectly the amount of coronary blood flow as well as the consumption of oxygen by the heart muscle [189, 218]. For example, in the resting state, with a pulse of 75 and a systolic pressure of 120, diastolic pressure = 90 and the coronary blood flow is 85 ml/min/100 gm of heart muscle.

However, under maximum stress with a pulse of 190 and a systolic pressure of 170, this index rises to 323, and in this situation, coronary blood flow calculates to 345 ml/min/100 gm, that is, directly proportional to the increase in "double product" [218]. Furthermore, Robinson [290] and Amsterdam [86] showed that anginal attacks always occur at one particular "DP" in a given patient; i.e., the painful symptoms actually occur at a specific critical level of myocardial oxygen consumption. This level can be predicted by using the "double product." That's why the determination of this index is commonly used during rehabilitation of coronary patients, right along with the determination of VO_2 and tolerance for exercise.

With increasing fitness, the "double product" value decreases both at rest and in response to a standard stress (e.g., 300 kg/min for women and 600 kg/min for men) as a result of more efficient use of oxygen by the heart muscle [94, 199, 263]. At threshold work loads, this index rises along with an increase in physical working capacity and work intensity [78, 95]. Hellerstein [181], in working with 100 coronary patients post-heart-attack over a three year period, has observed a 20% increase in "double product" at a threshold load; and, moreover, the appearance of myocardial ischemia on EKG developed at a higher value of the "double product" when compared with test results obtained prior to their exercise programs. Sanne [297] noted an increase of "double product" from 226 to 241 after nine months of intensive training and also noted that the stress level at which pain occurred had doubled. Referring again to the long-term study of post-heart-attack patients by the Soviet Institute of Cardiology [78], the group of patients who did physical exercise increased their "double product" levels at submaximal loads from 151 to 217, while the control group showed no change [168, 169]. Also, patients who began with a higher exercise tolerance, increased it from 250 to 285 over two years of training.

Thus, we can conclude, on the basis of "double product" dynamics, that intensive physical training by post-heart-attack patients increases the ability of the heart muscle to use oxygen efficiently under increasing work loads and, at the same time, to reduce myocardial oxygen demand because of more efficient oxygen consumption. As a result, the "threshold" for angina increases, as does the patient's ability to carry out activities and exertion.

We need to emphasize that the effectiveness of a rehabilitation program is not equal from patient to patient. Success is achieved only by those patients who have an initial exercise tolerance of at least 450 kg/min. If this index is less than 300 kg/min, then training fails to achieve any measurable success. Thus in a group of "strong" patients with an initial exercise tolerance of 600 kg/min, increases of stroke volume, minute blood volume, and exercise tolerance were all observed after one year of regular training, while in a "weaker" group with exercise tolerance of 430 kg/min, no change was observed in any of these indices [46].

Post-heart-attack patients also have very different abilities with respect to fitness running. No universal recipe can be offered here. Many patients are actually forced to limit their physical activities and need the constant use of medications for angina. How dare we speak to these folks about running? And yet some post-heart-attack patients successfully run long distances.

The contractile function of the heart muscle, its tolerance for stress, and the possibility of fitness running are all determined by the state of the coronary blood vessels [143, 238]. With damage to three coronary arteries, completion of a rehabilitation program does not seem to lead to significant improvement in the functional abilities of the heart nor to any improvement in tolerance for exertion or work capacity. By contrast, however, where there is narrowing of only one artery, work tolerance and capacity increases by 30% and actually reaches the level of healthy people [143]. Arterial patency (the extent to which blood flow can still occur through or "around" a narrowed spot in a diseased artery) is determined most exactly by the method of coronary angiography. In these x-ray "movies," the lumen of the coronary vessels and the places of their narrowing (stenosis) are clearly seen. Such studies, however, are available only in the setting of specialized cardiology centers. For "mass examination" of coronary patients, EKG is a quite suitable technology. This method, with the help of indirect signs and symptoms, can provide an adequate picture of the condition of the coronary arteries.

One objective reflection of the state of the coronary vessels is the changes in the ST segment of the EKG during a stress test on a bicycle ergometer. According to statistics obtained at the Kiev Institute of Cardiology [65], with damage to only one coronary artery, no ST segment depression is noted during stress testing, and a high tolerance for exercise (75% of VO_2) is maintained without appearance of anginal chest pain. When stenosis of three arteries is present (narrowing of the lumen more than 75%), ST segment depression is seen as a rule, and it is not possible to reach the submaximal level of stress because of the appearance of anginal pain. Investigators at the Boston Medical Center have confirmed the very high prognostic value of ST segment dynamics in coronary patients during stress testing. With ST depression of more than 2 mm, the risk of death from infarction was ten times higher (20%) than the risk for patients without signs of myocardial ischemia on EKG [334].

All of this foregoing information must be taken into consideration when making decisions regarding the advisability of fitness running for post-heart-attack patients. Patients with a high tolerance for exertion and lack of any EKG signs of myocardial ischemia during stress testing can appropriately begin running or other exercise programs in private individual settings. In those cases where initial exercise tolerance is found to be low, or ischemia of the heart muscle is found on the stress test, fitness walking and strictly dosed work on a treadmill or exercise bike are more expedient.

However, physical training is desirable in every case, for without it, the condition of post-heart-attack patients becomes worse regardless of the initial tolerance for exercise or the extent of damage of the coronary arteries. Thus, in the group of "strong" patients who had high tolerance for exertion during their initial examination, but who did not take part in programs of physical rehabilitation, a change for the worse was noted in all the indices of circulation. The number of patients with insufficiency of circulation increased from 14% to 25%, and the number with coronary insufficiency increased from 25% to 50% [46]. By contrast, in the group of "weaker" patients, who participated in physical exercise (fast walking and slow running for 30-60 minutes three times a week) over three years, the signs of circulatory insufficiency disappeared, and the number of patients with coronary insufficiency decreased from 30% to 6%.

Referring again to the study of the Soviet Cardiology Institute [3], during a three year follow-up, in the group of patients who regularly exercised according to a protocol of physical rehabilitation, a repeat heart attack was observed in 10% of cases. By contrast, in the control group, pursuing a very inactive life style, repeat heart attack occurred in 26% — 2.5 times more frequently! According to a study at the Warsaw Rehabilitation Center [58], the prime group of patients (in an exercise rehabilitation program) experienced a repeat heart attack rate of 4.5% over a four year period during which a control group experienced a repeat heart attack rate of 20.6% — or 4.5 times more frequent. In the rehabilitation center in Toronto, Canada, 1,318 post-heart-attack patients were observed over a four year period. In the group of patients who participated in training (walking and running), the mortality rate was 30% lower in comparison with a control group who did not participate in physical exercise [312]. The data collected over ten years of observation of 260 patients from University Hospital in Cleveland (table 21) give a graphic picture of the obvious differences in the functional state of post-heart-attack patients depending on their level of physical activity. The first group followed a physical training protocol, and the second group did not.

STAGE OF RESEARCH	RESTING PULSE		SYSTOLIC BLOOD PRESSURE		DIASTOLIC BLOOD PRESSURE		EXERCISE TOLERANCE IN Kg./min.	
GROUP	1	2	1	2	1	2	1	2
BASELINE DATA:	75	74	136	125	88	84	530	530
AFTER 10 YEARS:	58	71	122	136	82	90	840	580

Table 21. Indices of the condition of the cardiovascular system in groups of patients with different physical activity levels (based on ten years of observation of post-heart-attack patients): from Franks, 1983 [162].

Walking and running as rehabilitative measures are also used after heart surgery [4] and even after heart transplantations [316]. The formerly limited use of fitness running is steadily picking up.

However, the issue of safety in these rehabilitation programs remains alive. Although a great deal of experience indicates that there is minimal risk in these physical training programs, it is still most important to provide a totally controlled setting with medical staff on hand during the first year after the heart attack.

Naughton [261] has not observed a single serious or life-threatening complication during many years of supervising post-heart-attack patients in programs of intensive physical training. The All-Union Soviet Cardiology Institute has accumulated similar data [78]. In the group of 105 coronary patients doing physical training, the only complication was a repeat heart attack in one patient who was successfully revived [297].

Hakuila [173], in training 800 coronary patients, noted ventricular fibrillation in only one case, and this was treated successfully with immediate defibrillation. In the course of testing over one million patients with cardiovascular disease in the Cardiology Clinic in Frankfurt am Main (West Germany) [336], ventricular fibrillation was observed at a rate of only one case per 15,000 investigations. According to the statistics of the scientific council of the American Medical Association [313], the danger of cardiac arrest in the course of rehabilitation programs ranges from 1:900 to 1:32,000 person-hours of exercising depending on the severity of the disease state in coronary patients.

However, in a rehabilitation center in Toronto, where 5,000 patients did training over a 13 year study, the incidence of cardiac arrest was found to be considerably more rare—only one in 113,000 person-hours of training [212] and, according to Haskell's statistics [176], only one in 200,000 person-hours of training occurred. Moreover, all the patients in these studies were revived!

Mortality statistics on patients being treated in a cardiology clinic are the same as those for patients who participate in intensive physical training [313]. Hence, the risk of sudden death in patients who run is no greater than it is for those who remain at rest, and the physical training in these cases is quite justified. With careful selection of patients and consideration for their individual exercise tolerance, exercise helps the post-heart-attack patients recover their lost capacity for exertion and return them to normal work and activities in a relatively short period of time.

Patients with low exercise tolerance must have totally controlled training settings, while patients with more than 750 kg/min can pursue independent exercises at home with an assigned heart rate [143]. Breaking rules, or running without controlling the intensity of workouts, is a serious danger.

The positive experience of so many rehabilitation programs and the rising popularity of fitness running have been such that a few post-heart-attack patients have even participated in marathon events. But such training is attacked by critics [184]. In the first place, it should be admitted that the majority of post-heart-attack patients are not capable of taking part in a marathon. Second, even if they are capable of running 42 kilometers, it would not improve their clinical state. Third, in such persons as these, inclined to heart attacks, intensive physical training represents an added danger of sudden ventricular fibrillation and cardiac arrest. It makes no sense to knowingly take on such a heroic project when it is possible to achieve the same goal via less dangerous and "smaller means," practicing a regular daily training program.

Besides, it is impossible to predict who will be capable of running a marathon distance and who will not. Yet setting such an unrealistic goal and ultimately failing can have a negative psychological influence on a patient and lead to a depressive state [314]. Don't forget that completing the marathon distance causes physiologic shifts bordering on the pathological and places the body in extreme circumstances, even when the runner is quite healthy. Surely then it is much less advisable for people with cardiac problems. We fully share the opinion of the marathon opponents, not only in regard to patients who have had a heart attack, but for any patient who has any instability of cardiovascular function.

RUNNING AND DISEASES OF THE VESSELS OF THE LOWER EXTREMITIES

Varicosities of the lower extremities are NOT a contraindication to training. In fact, rhythmic exercises promote venous blood flow and improve peripheral circulation. Running is especially effective, as muscular contractions of the leg push blood in the direction of the heart and eliminate venous congestion.

Cooper [122] notes a favorable influence of running on peripheral circulation with varicosities. For three years we have been observing two men after surgical removal of varicose veins in both lower extremities, who then successfully participated in fitness running without any complications. The only advice seems to be that it is good to wrap the legs with elastic bandages prior to prolonged runs, and also that it is good to lie in bed with the feet elevated for a few minutes prior to going to sleep at night.

However, when there are complications (e.g., thrombophlebitis), running is strictly prohibited, for the active pushing of blood through an inflamed vein can lead to thromboembolism (breaking loose of a blood clot that might pass into the pulmonary artery). For this reason, whenever there are even minor signs of inflammation (redness, tenderness, swelling, or "hardness"), it is necessary to stop the training program immediately and consult a doctor.

Walking and running are also effective in cases of arteriosclerotic damage to the vessels of the lower extremities in the first stages of the disease. In the course of training it is possible to increase the distance that a patient can complete without the appearance of pain. Cooper gives examples of the positive influence of dosed running in the first stages of arteriosclerosis, and even in the more serious condition of endarteritis in the lower extremities. He reports that vascular tone normalizes, peripheral resistance decreases, and collateral circulation is encouraged to develop around the blocked arteries.

So far, there has been only a handful of studies in this area. S.V. Goncharenko [23] used running as a remedy in 28 men aged 50-75 with arteriosclerosis of the lower extremities in the first and second stages. The distance of continuous running increased gradually from 3 to 8 kilometers. After four years of regular training, pains totally disappeared in 23 of the patients and considerably diminished in three of the others. In critical cases (stage III of the disease), where actual organic changes in the vessels are present, there seemed to be no effect from the exercise program.

Things are more serious with endarteritis since both the large arteries as well as the smaller blood vessels (arterioles) are damaged. However, positive and beneficial results from running can be expected even in this disease process in its early stages. Interesting facts are reported by L.A. Pirogova [55], who prescribed dosed walking and running to 103 patients with occlusive endarteritis as well as arteriosclerosis of the lower limbs in the setting of a cardiovascular sanitorium. Prior to a workout, a functional test was given to each patient — 30 bends of the foot while lying on the back. Patients with compensated and subcompensated forms of the disease (stages I and II) developed so-called "exertional hyperemia" several minutes into the test — a normal response caused by increased blood flow in the working muscle groups of the leg. Such patients tolerated the stress of the training program well, and a number of positive changes in the cardiovascular system were noted in such patients: an improvement in the contractility of the heart, a drop in blood pressure, and an increase in exercise tolerance.

Patients with a decompensated form of the disease (stage III) demonstrated vasospasm in the leg in response to the functional test, and this caused the development of pain ("claudication"). Physical training in such a situation is contraindicated.

RUNNING AND NEURASTHENIA

Neurasthenia is a disease of our present century which develops as a result of hypodynamia (reduced physical activity), excess information, and chronic anxiety as a result of constant pressure, time urgency, and negative emotions.

K.F. Nikitin considers running to be the best means of treating neurasthenia. After a six week course of treatment in a neurologic sanitorium, which consisted of alternating running and walking as well as hydrotherapeutic procedures, he observed disappearance of all the symptoms of the disease in 100% of cases.

RUNNING AND GASTRO-INTESTINAL DISEASE

Investigations concerning the influence of physical training on the function of the gastro-intestinal tract are not numerous. It is known that an easy short workout of the "warm-up" type, fast walking, or training in fitness groups stimulates the function of the stomach. As a result, gastric secretion increases, and the activity of the biliary system increases. Intense or prolonged physical stress, however, hinders digestion and causes gastric secretion and motility to decrease.

In studies on humans, the following results are obtained. After a long rhythmic endurance workout, both cyclists and runners showed a considerable increase of acidity in their intestinal secretion. Training on an exercise bicycle for 30 to 60 minutes led to the same result [39].

Based on these observations, we can deduce that running is advisable for diseases and conditions of the stomach where there is reduced acidity (ulcer disease, achlorhydric gastritis) as it stimulates both the secretory as well as the motor function of the stomach. In the case of diseases with hyperacidity (ulcer disease, hyper-acidic gastritis, etc.), some data suggest that running may be inadvisable because it can increase the acidity of the biliary secretions. However, one must not forget that physical training increases our body's immunity and improves our general strength. Furthermore, an adequate exercise regimen promotes normalization of dysfunctional activity in the cortex of the brain, which is of considerable importance in the pathogenesis of ulcer disease. Therefore, whatever is the acid character of stomach secretions, running is considered to be useful in cases of stomach disease, though, naturally, not during the period of acute symptoms.

In cases where there is a problem with reduced biliary acidity, it is enough to drink a half-glass of water before running, and this will increase gastric secretion. The duration of "Sunday running" should not exceed one hour. Longer workouts can lead to suppression of gastric secretion. In order to neutralize the acid content of the stomach, we advise our patients, especially where hyperacidity is a problem, to drink an oatmeal concoction (which is alkaline) prior to running. If this advice is complied with, the length of the "Sunday runs" (if the level of fitness permits) can be increased to 2 hours.

Such methods have proven themselves successful through the years and have been used without complication by those who pursue fitness running as well as by competitive athletes.

Distance running has been found to be a good remedy for spastic colitis. It seems that the vibration of the intestine as well as the secretion of magnesium salts into its lumen greatly increase peristalsis and seem to improve an abnormal or "lazy" excretory function of the intestine better than any medicinal remedy.

Running can also be useful in disorders of biliary function (biliary dyskinesia), as it normalizes the tone of the biliary ducts and promotes the outflow of bile —especially if it is used in conjuction with the abdominal type of breathing. During inspiration, you need to protrude the abdomen as much as you can, while during exhalation, you need to draw the abdomen in. The chest is almost immobile in this type of breathing. It is necessary to master this technique called "abdominal breathing" at home—first lying on your back, then sitting on a chair. During exhalation, the liver is presssed between the diaphragm (the partition between the abdomen and the thoracic cavity) and the spine, and as a result the outflow of bile into the lumen of the duodenum is facilitated and liver function is improved. When we consider that oxygen use by the liver is increased 2 to 3 times during running, then the combined influence of these two factors is hardly overestimated.

The methodology of running combined with "abdominal breathing" in cases of liver disease has been worked out by a "running doctor" from Kaluga, Shamil Araslanov [6]. The first stage of treatment (4-6 weeks) involves a program of walking at "variable speed" with bursts of rapid walking for 30-40 meters and 4 minute intervals of slow walking or rest. Then the rapid walking is replaced by slow running in the same protocol. During all the training, "abdominal breathing" is used with brief inhalation (1-2 steps) and prolonged exhalation (3-5 steps). A preliminary dose of a biliary secretory stimulant and an antispasmodic are given to increase the outflow of stagnant bile. Often the disappearance of pain occurs right during the exercise. Araslanov cites an interesting example of complete elimination of painful biliary colic after two months of regular training on this protocol.

RUNNING AND DIABETES

Diabetes is a very common and widespread disease that involves a disturbance of metabolism aggravated by hypodynamia (too little exercise) and obesity (too much nutrition). It increases the risk of developing coronary heart disease to twice or even three times the normal risk.

The treatment of diabetes is rather "passive" in nature and involves the limitation of carbohydrates in the diet and the taking of insulin preparations to replenish the body's defective ability to secrete its own insulin.

Whenever diabetes is severe and uncontrolled _ where insulin can no longer normalize the blood sugar or where there are sharp drops in the blood sugar levels _ running is contraindicated since it can induce dangerous fluctuations in the blood sugar levels [214]. In diabetes of only mild or moderate severity, fitness walking and running are of definite benefit. The body's sensitivity to insulin improves, so for any given insulin level in the blood, the liver is enabled to metabolize sugar better in those who exercise [330].

And let's not forget the indirect benefits of rhythmic exercises—the facilitation of fat metabolism, reduction in body mass, and normalization of blood pressure [214]. Regular distance or endurance training markedly increases the effectiveness of the treatment of diabetes. Exercise causes an improvement in attitude and mood as well as an increase in exercise tolerance, a reduction in resting heart rate, normalization of blood sugar levels, and a reduction in the required daily dose of insulin (by 25% on the average) [200].

Running is particularly effective for juvenile diabetics. Whenever they participate in sports, their functional abilities increase exactly parallel with those of healthy children [229]. However, speed and strength (as opposed to endurance) exercises are not recommended for them since they cause sharp increases in blood sugar levels and have little effect on consumption of fats or carbohydrates [330].

In summary, long slow running can be very beneficial in diabetes. However, for patients requiring insulin, it is necessary to monitor blood sugar levels in the early stages of training, for when blood sugars are not stable, prolonged running can increase the hypoglycemic effect of insulin and might cause a dangerous drop in the sugar level!

RUNNING AND "THOSE EXTRA POUNDS"

Excess weight can considerably complicate a program of fitness running, because an obese runner places an extra burden on his/her cardiovascular and musculo-skeletal systems. For persons of average body construction, normal body weight (in kilograms) can be calculated by subtracting the number 105 from their height in centimeters (Americans, British, Canadians, etc. will have to refer to a standard "height-weight chart"). Small-boned or "frail" persons should subtract 5 from the result, while large-boned or muscular persons should add 5.

Cooper [122] teaches that if body weight is more than 20 kilograms above normal, then training should begin with fitness walking. During the transition from walking to running, beginners who are overweight should abide by the following set of rules in order to prevent injuries to the musculo-skeletal system [63].

—At first, seek only level and softer surfaces if possible (alongside stadium paths or park paths).

— Combine running with walking for a long period of time.

—Lift the feet only a minimal height off the ground to lessen the vertical stress on the body and the intensity of footfall impact. (The former famous American long-distance runner, Bill Emmerton, who is now a proponent of fitness running, writes about this in his book.)

—The placement of the foot on the ground should be done using the whole foot, from top to bottom, just as one walks on a stairway, which softens the impact of each footfall.

—The stride length should be minimal at first—one and a half or two feet.

—Run only in well-built running shoes with a well cushioned sole and good support for both arch and instep.

—If you have flat feet, do regular exercises to strengthen the ankle joint and foot muscles.

The most important consideration for prevention of injuries is to limit the training sessions to 20-30 minutes three times a week in the first few months. Later, the workout time can be very gradually increased. By then, the muscles, ligaments, and joints will have had enough time to strengthen and adapt themselves to running. Limiting the workout load is necessary for one more important reason: that with increased weight, the work load on the heart increases proportionally. The famous specialist in the sphere of running, S.P. Suslov, teaches that if a person abides by all of the above precautions, then excess weight is not an obstacle to fitness running.

Our actual experience also confirms this. About 75% of our runners weighed in more than 10% above normal body weight. Eighteen of our runners (15 women and 3 men) weighed more than 20 kg over "normal." Almost all of them who showed enough patience and persistence achieved the desired result of weight loss, practically to normal, and achieved great success with fitness running. Thus for example, patient E.S., 34 years old and 180 cm tall (5'9"), weighed 105 kg (231 pounds). As a result of fitness running, he dropped his weight to 80 kg (176 pounds) over two years. His weekly running distance reached 60-80 km. Another example was patient V.N., 50 years old and 176 cm tall (5'7") whose weight was 105 kg (231 pounds). Over five years, his weight dropped to 70 kg (150 pounds). His weekly running distance was 60 km.

Females did not lag behind in this respect. G.M., 30 years old and 164 cm tall (5'5"), began her program weighing 90 kg (198 pounds). Combining fitness running with slight reductions in her diet, she reduced her weight to 60 kg (132 pounds) over three years. Her weekly distance never exceeded 30 km. She now takes part successfully in All-Union 20 km running events; her personal best is 1 hour 50 minutes.

Weight reduction is possible only if daily energy expenditure exceeds food intake ("negative caloric balance"). A group of American scientists studied 6 women with fourth-stage (severe) obesity. Their daily diet averaged only 2,300 kcal and their energy expenditure was even less—2,200 kcal. Training in the form of walking on a treadmill for 4 weeks with an increased daily energy expenditure of 25% with the same dietary caloric intake led to an average weight reduction of 2.3 kg (5 pounds) and a reduction of 1.2 kg (2.6 pounds) in body fat mass during this period [342].

Twenty minutes of walking at 6 km/hr demands an energy expenditure of 100 kcal, which is equivalent to a 1 kg (2.2 pound) loss of fat tissue each month [9]. However, with such small expenditures of energy (300-400 kcal/hr) it is difficult to achieve a substantial amount of weight loss by walking alone, without some effort at dieting. One small pastry and a glass of milk (350 kcal) completely neutralizes your entire effort of one hour's walking. Likewise, it is difficult to achieve success by dieting alone, because obese people, living a sedentary lifestyle, have a very reduced fat metabolism and a very limited energy expenditure.

One can best achieve a reasonable goal of weight loss only by combining a regular program of prolonged fitness walking with a reasonable limitation of calorie intake—especially limiting carbohydrates and fats.

It is very important to avoid eating for 1-2 hours after your workout, so that the intensified burning of your own stock of fats may continue "by inertia." It is also necessary to limit the evening meal to fruits, vegetables, and buttermilk, because food taken at night tends to add to the body's fat stores.

Distance running tends to promote weight loss for one other reason. It suppresses the appetite, as we've mentioned above. On the days of long (Sunday) training workouts, our runners as a rule do not have breakfast and take food only later in the day in very small quantities (oatmeal, cottage cheese, eggs, fruits, and salads). Such a reduction in the body's demand for food is easy to explain from the point of view of the brain, which is prone to "motor domination." The dominating focus of excitement in the motor centers of the cerebral cortex (caused by prolonged running) suppresses the activity of the brain's appetite center for quite some time.

RUNNING AND INJURIES

The potential for musculo-skeletal injuries during fitness running is often the subject of lively debate. The strongest detractors of running contend that the human musculo-skeletal system, the bones and joints, are not adapted to movements that cause such great stresses as occur when the feet are struck against hard ground. But the enthusiasts and supporters of slow running, such as Cooper, refer to this doubt-ridden theory as "a myth about running." We will try to discuss this problem impartially.

Let us focus on the physiologic influence of running on the musculo-skeletal system. There is no doubt that a regular and methodically correct program of distance running has a positive influence on all components of the musculo-skeletal system, preventing the developent of degenerative changes connected with aging and hypodynamia [89, 195, 232, et al.]. Reduced flow of articular fluid (lymph) as a result of insufficient stress on the joints leads to a disturbance in cartilage nutrition and loss of elasticity, which promotes development of arthritis [232]. This is why the primary cause of joint and spine diseases in middle aged people is hypodynamia, which causes a decrease in muscle tone and an increase in the stress on ligaments, articular cartilages, and intervertebral discs, as well as a worsening of their nutrition [89].

Rhythmic exercises (such as running, cycling, etc.), as a result of their rhythmic alternating contracting and relaxing of the muscles, greatly increase the lymphatic flow to the articular cartilages and intervertebral discs, which is the best prevention against arthritis and radiculitis ("pinched nerve") [89, 90]. Running on the soft forest ground has a vitalizing effect and is of special benefit to the knee and hip joints. The famous sports physician, E. Deuser, writes that "long distance runners and cyclists have exceptionally healthy and well-functioning joints while they are active in these sports" [138]. Cooper notes that during x-ray examinations of 74 international class distance runners, only half as many bone injuries were found as compared with nonrunners.

Also very important is the increase in bone density and periosteal enlargement seen in runners as a result of better assimilation of calcium salts. These changes prevent malacia of bone tissue (osteoporosis), which is the main cause of bone fragility in older people. The thickness of muscular fibers increases, as does the strength of the muscles, while both the strength and elasticity of tendons increases [90].

There is no doubt about the beneficial influence of running on the musculo-skeletal system. However, the untrained ligaments, muscles, and joints of middle aged and elderly people can become the cause of many complications if workouts are increased too ambitiously. This is the principal cause of musculo-skeletal injuries in fitness running [160, 203, 255]. F.L. Allman describes the nontrained status as the syndrome of "the three Fs"—forty, fat, and flabby. "Many people try to return to their former level of physical fitness with the help of fitness training," Allman writes, "and begin to train with the same intensity as 20 years ago."

Additional factors predisposing to injury are running on a hard or uneven surface, excess weight, improper shoes, and errors in running technique. Thus to prevent injury, steps should be taken to eliminate or attenuate these factors.

First, it is necessary to eliminate the main cause of injury in runners: overstrain in the undertrained. Cooper [122] writes that the incidence of injuries among beginners rises sharply when the weekly running distance exceeds 20 km. For this reason, beginners are advised to limit their workouts to 30 minutes three times a week for the first three months, and this will keep the weekly distance at about 15 km. If beginners train more than three times a week or run more than 30 minutes, then the incidence of injuries rises [282]. Injuries can also be caused by running too fast or over too rugged terrain.

Specialists from the Orthopedic Clinic of the Medical Academy in Erfurt (East Germany) teach that the frequency, distance, and intensity of the workouts should be regulated so that the runner will not develop complications of the musculo-skeletal system on the days of rest [90]. If pain occurs in the muscles or joints, the workout schedule should be immediately reduced.

Strengthening of the musculo-skeletal system with the help of special exercises is also of great importance for prevention of injuries. Stretching exercises for the calf and thigh (bends, etc.), hot baths for the feet, sauna, and massage can be useful. As the runner's level of fitness and preparation increase, the weekly mileage and frequency of workouts can be gradually increased.

Running on a hard surface is an additional danger for an untrained beginner. The harder the surface, the more risk there is for an injury. According to surface hardness, roads with different surfaces are listed in the following order: concrete surface, asphalt roads with a concrete foundation, plain asphalt surfaces, dirt roads, cinder track, road shoulders, and artificially-surfaced tracks. However, training even on very soft ground can result in injury. On sand or very rain-soaked ground, the heel-strike and backward bending of the foot during a workout can lead to an overstrain of the posterior shin muscles or an injury to the Achilles tendon. For this reason, it is better for beginners to run along stadium tracks and forest paths. It is best to avoid asphalt during the first few months. In winter, a tightly pressed layer of snow is the best surface for running, for it prevents muscles and joints from overload. As your fitness level increases, you will need to gradually include some runs on harder surfaces. Leedyard [42] teaches that the best means for strengthening the musculo-skeletal system for seasoned runners is periodic variation of routes to include different surfaces—cinder tracks, asphalt, forest paths, etc.

Improper shoes can also do a runner harm. It is desirable for the shoes to fit the surface. Sneakers with thick-cast soles a "half-size too big" will be the best thing for long runs along a highway. The French orthopedist Steinmetz recommends two tests to help select the right shoe: the flex test—the shoe must bend easily in the metatarso-phalangeal (toe) portion of the shoe to allow for active push off and the twist test—a good sole should NOT twist (around the longitudinal axis) in its middle area; such resistance to twisting will provide stability for the foot in the critical arch area. Steinmetz recommends against shoes with either too soft or too thick soles (which are being manufactured now) because the heel in them "falls" just as when running on rain-soaked ground that is too soft.

For running in the forest or along a stadium track, it is better to chose light shoes with thin soles, because here the likelihood of injury is more remote. For winter running, it is best to use shoes with a "tire-like" tread in the sole, in order to prevent slipping and the danger of a fall. The usual light running shoes—one size larger than your usual size—with an additional insole and heavy woolen socks are suitable. But avoid lacing them up to the top, in order to keep mobility in the ankle joint.

We've already mentioned and listed the various means of preventing injuries for overweight runners. Now we need to eliminate the principal errors in the technique of running. Let's mention the most frequent (figure 17).

TURNING THE FEET SIDEWAYS. When running in this manner, the push is directed to the side and, as a result, the body's forward motion and speed are diminished. Furthermore, the resulting lateral vector of vertical stress can lead to joint injuries. The runner's feet must be as parallel to one another as possible. This will increase the speed and efficiency of the running and reduce the danger of injury. With correct foot position, there should be only one straight line of footprints along the path (see figure 17), while turning the feet sideways results in two rows of footprints.

During fitness running, the footfall (placement of the foot on the ground) should preferably land on the heel and never on the toes, for "toe-striking" can lead to overstrain of the ankle muscles and injury to the Achilles tendon. Yet the runner should avoid vigorous "heel-striking" with the blow of the footfall directly on the heel's edge, as this can lead to excessive stress on the lower extremities and the spine. Therefore, it is best to land with the middle of the heel and the forefoot simultaneously and glide into a soft roll toward the toes. With these mechanics, inertial forces are minimal, there is no "braking," and speed is not sacrificed.

UP-SPRINGING (the "galloping run"). The push should always be directed forward, for this is what will minimize the vertical undulations of the center of gravity and results in the most economical energy expenditure. It is the marathon runner, forced into maximal economization of his/her energy resources, who has the most efficient technique of running. Even in middle-distance running, the advantages of the low and smooth stride are obvious.

WORKING THE ARMS ACROSS THE BODY. This causes lateral (side-to-side) undulations and body swinging, which in turn reduces speed and can result in injury to the knee joints. The arms should move freely back and forth almost parallel to one another without crossing the body's central axis.

Injuries to the musculo-skeletal system can partially depend on the speed of running. The French traumatologist J. Turblin [325], in his article "Foot-running —yes, jogging—no!" gives a thorough analysis of the biomechanics of slow and fast running from the point of view of propensity to injury. At a running speed of 10-12 km/hr (foot-running), the aerodynamic properties of the legs and the pelvis are used maximally; the push is directed forward and the vertical undulations of the center of gravity are minimal. Such running is most physiologic and provides the most economical expenditure of energy as well.

Slower running at speeds of 7-9 km/hr (jogging) very much resembles running in place from a biomechanical point of view. The push is directed upward rather than forward, which increases vertical undulations (galloping), wastes energy, and predisposes to injury. It must be noted, based both on the literature [122] and our own many years of observation, that the overwhelming majority of experienced amateur fitness runners train at an average speed of at least 10 km/hr. Only the beginners and those with serious health problems run slower. And such faster running is a wonderful means of developing endurance and protection against a number of illnesses with only minimal risk of injury. Yet we want to warn the beginning amateurs, especially the very impatient, about the danger of rapidly increasing their speed and about the need to increase their workout loads very slowly and gradually. If they comply with this advice, then their jogging will naturally develop into real running that is light and lithe and can be counted on to strengthen the heart and prevent injury.

And yet, in spite of all these preventative measures, beginning runners may develop soreness in the legs and other locations. We'd like to give a catalog of common injuries based on the data of various authors [6, 102, 196, 234, 244, 280]. At the very beginning of a training program, sharp pains may develop in the calf muscles—sharp and "bursting" type pain like a severe bruise. Most often, such pains trouble women during the transition to shoes without heels, i.e., running shoes.

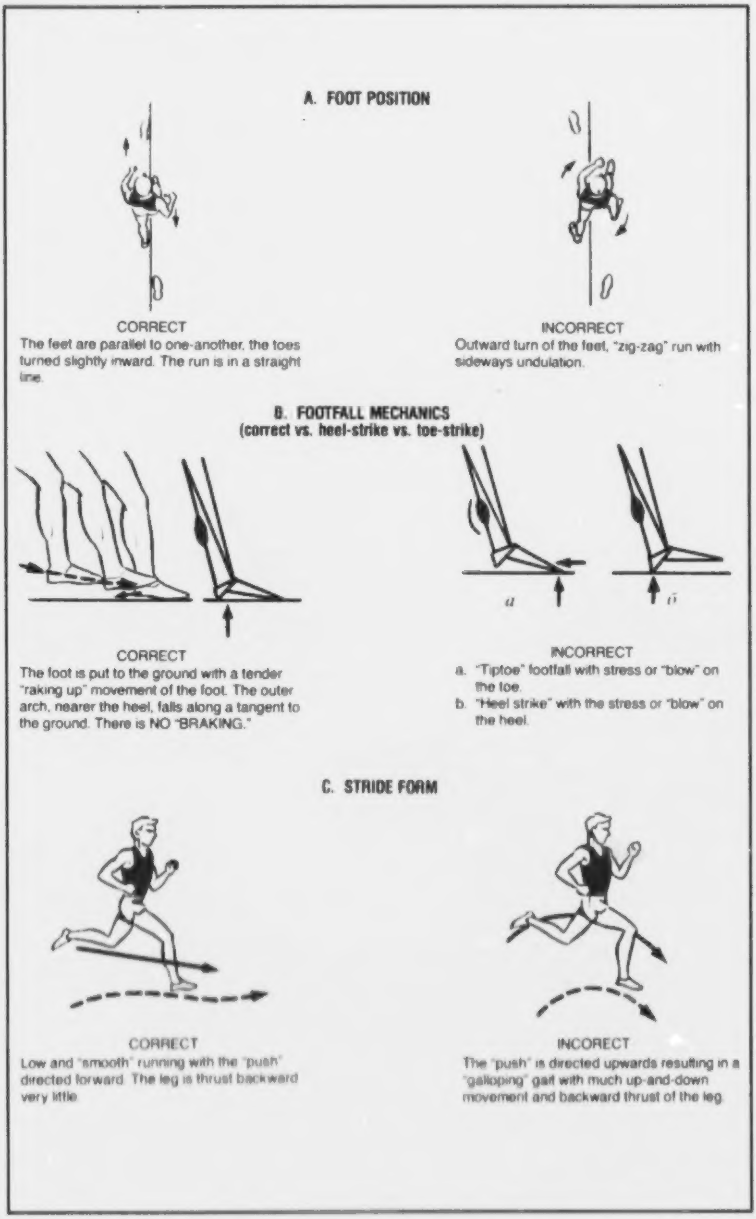
The second most frequent complication may be pains in the feet. Usually they appear when some abnormal condition is present, such as flat feet, hammer-toe, or a heel spur. With weak arches, strained plantar ligaments are common. With running on a hard surface, traumatic arthritis of the big toe occurs, and with improper footfall onto the toes, metatarsal injury occurs. With prolonged excessive workouts, even experienced runners may develop a stress fracture of the third metatarsal bone (march fracture). Shoes that are too small can lead to hemorrhage beneath the toenail (subungual hematoma) as a result of repetitive stress against the hard edge of the running shoes.

Running on a hard surface, running on tiptoes, or rapid increase in the workout load can lead to injury of the Achilles tendon. Pain, swelling, and redness appear in the area of the tendon. To cure this, it is necessary to stop training and begin physical therapy (ultraviolet, ultrasound, paraffin treatment, etc.), according to your doctor's advice.

Too frequent or prolonged running on a hard surface can produce inflammation of the periosteum (the leg bone's tough surface lining). The symptoms are pain in the lower part of the leg's inner surface after prolonged running. The remedy must be cessation of training and physical therapy.

Pain in the low back as a result of radiculitis (irritation of a nerve root caused by pressure from one of the discs) is a common problem in people over 40. The cause of this condition is degenerative changes of the vertebral discs usually resulting from too little activity, weakening of the muscle tone in the lower back, and disturbances in nutrition of the cartilage.

Muscular back aches can also appear in runners, especially in the first stages of their training program. The main preventative measures are to avoid hard surfaces in the beginning, to run in good running shoes, and to do exercises to strengthen the muscles of the abdomen and low back, which form the "muscular corset" supporting the spine.



A. FOOT POSITION

CORRECT
The feet are parallel to one-another, the toes turned slightly inward. The run is in a straight line.

INCORRECT
Outward turn of the feet, "zig-zag" run with sideways undulation.

B. FOOTFALL MECHANICS
(correct vs. heel-strike vs. toe-strike)

CORRECT
The foot is put to the ground with a tender "raking up" movement of the foot. The outer arch, nearer the heel, falls along a tangent to the ground. There is NO "BRAKING."

INCORRECT
a. "Tiptoe" footfall with stress or "blow" on the toe.
b. "Heel strike" with the stress or "blow" on the heel.

C. STRIDE FORM

CORRECT
Low and "smooth" running with the "push" directed forward. The leg is thrust backward very little.

INCORECT
The "push" is directed upwards resulting in a "galloping" gait with much up-and-down movement and backward thrust of the leg.

Figure 17. Typical mistakes in the technique of running.

Injuries in fitness runners as a rule disappear after a little rest and appropriate treatment and usually cause only temporary interruption of the training schedule. When resuming training, the workout load must be increased very gradually to prevent the unpleasant episode from recurring.

Remarkably, none of the numerous studies dealing with orthopedic and traumatologic problems in fitness running give any statistical data about the frequency of injury in amateur runners. This can be explained by the fact that only the injury itself has been studied in a few runners who have sought medical care, but the traumatism has not been studied in the KLBs (Clubs of Running Enthusiasts, which have large memberships in every city and town in the Soviet Union).

Thus, for example, the Norwegian Nilsson writes that "The incidence of injuries in fitness training programs is insignificant" [266]. Scientists from East Germany [90] note that excessive distance running can cause development of arthrosis of the knee joint, but they do not cite any statistics. Even Cooper, who has a vast store of statistical material at the Dallas Aerobic Center, notes only the increased danger of injury from increasing the weekly distance-load above 40 km. The actual incidence figures are still unknown.

We therefore consider that it might be useful to share the experience of our own work. More than 300 amateur fitness runners from ages 30 to 65 were under our observation for five years (1980-1985). In the first few months of the studies, calf pain of various intensity troubled many women (about 30%), only two of whom had to discontinue their program. The rest of the women runners successfully endured these early difficulties and continued their training programs. Achilles tendonitis afflicted only one man (age 40) and was quickly relieved by a course of physical therapy. Inflammation of the periosteum of the tibia (shinbone) occurred in only one runner after rapid increases in his workout load while preparing for a marathon. He received physical therapy during a two-week layoff from running, and these measures quickly healed the problem. Knee pain was noted in two beginners. One of them was diagnosed with arthroses of both knees. With a simple reduction in the workout schedules, both runners experienced gradual disappearance of the pain.

Thus, our data do not substantiate the claim that injuries to the musculoskeletal system can present a serious obstacle to a fitness running program. It goes without saying, however, that all the principles of training in middle aged persons should be followed.

Literature Citations

RUSSIAN LANGUAGE CITATIONS

1. Abbaakumov, C.A. Cardiology, 1980, 11, 36-39.

2. Aftandilov, G.G. Dynamics of the Atherosclerotic Process in Man, M., 1970.

3. Alexeyev, P.A. Aftoreferat lis. cand., 1975.

4. Amosov, H.M., Bendet I.A. Physical Activity and the Heart, Kiev, 1984.

5. Araslanov, S.A. Legkaya Athletika, 1983, 12, 24-25.

6. Araslanov, S.A. Legkaya Athletika, 1985, 9, 22-23.

7. Arinchin, N.I., Kulago, G.V., Minsk, 1969.

8. Aronov, D.M., V Kn.: Modern Modalities of Rehabilitation Following Myocardial Infarction, M., 1983, 56-68.

9. Arutunian, G.A. IV Caucasian Conference of Gerontologists and Geriatricians. Yerevan, 1980, 111-113.

10. Akhmedjanov, M.U. Voproci Kurortologii, 1980, 1, 35-39.

11. Babarin, P.M., V Kn.: Phyzicheskaya Kultura. . ., M., 1983, 56-68.

12. Bazhanov N.N. Cardiology, 1980, 11, 19-23.

13. Belotserkovskey, Z. Theory and Practice of Physical Fitness, 1984, 3, 51-53.

14. Belchenko, D.I. Hygiene of Labor, 1980, 11, 16-19.

15. Bogush C.V. Medical Affairs, 1981, 9, 51-53.

16. Bulyer F. Aging and the Aged, M., 1962.

17. Vasileyeva, V.V. Vascular Reactions in Sportsmen, M., 1971.

18. Volkov, V.M., Milner, E.G. Theory and Practice of Physical Fitness, 1981, 6, 9-11.

19. Volkov, N.I., Shirkovetz, E.A. V Kn.: Energetika. L., 1973, 18-30.

20. Gaynetdinov, N.M. V Kn.: Questions in Sports Medicine, L., 130-136.

21. Geisler, V. V Kn.: Modern Modes of Rehabilitation Following Myocardial Infarction, M., 1983, 28-34.

22. Gogokhia, N.D. Kardiologia, 1980, 6, 41-47.

23. Goncharenko S.V. IV Caucasian Conference of Gerontologists and Geriatricians, Yerevan, 1980, 146-147.

24. Graivskaya, N.D. The Influence of Sports on the Cardio-Vascular System, M.,1975.

25. Dyembo, A.G. Current Issues in Sports Medicine, M., 1980.

26. Dyslipoproteinemia and Ischemic Heart Disease (ed. E.I. Chazov), M., 1980.

27. Donskoy, D.D. V Kn.: Problems of Fitness Walking and Running (material from the All-U.S.S.R conference on fitness walking and running), M., 1983, 58-60.

28. Zhukovskey, S.P. Riga, 1976.

29. Zatsiorskey, V.M. Physical Qualities of Sportsmen, M., 1970.

30. Zatsiorskey, V.M. Physical Fitness and Sport, 1985, 6, 20-22.

31. Zubovskey, G.A. Theory and Practice of Physical Fitness, 1973, 3, 47-48.

32. Igumenov, V.M. V Kn.: Issues in Fitness Walking and Running, M., 1983, 8-14.

33. Israel, Z. Sports in Modern Society (World Wide Scientific Congress.), M., 1978, p. 238.

34. Myocardial Infarction. Proceedings of International Community of Cardiologists, M., 1976.

35. Karpman, V.L. Investigation of the Physical Work-capacity of Sportsmen, M., 1974

36. Karpman, V.L., Khruschev, C.V., Borisova, U.A. The Heart and Work-Capacity of Sportsmen, M., 1978.

37. Klimov, A.N. V Kn.: Preventive Cardiology, M., 1977, 260-321.

38. Kruglak, L.V., Roy, I.V. Physical Fitness, Work, Health, and Present-Day Longevity, 1981, p.118.

39. Kuznetsov, A.P. Theory and Practice of Physical Fitness, 1982, 7, 24-26.

40. Levando, O.N., V Kn.: Issues in Sports Medicine, M., 1979, 141-152.

41. Levando, V.A. Theory and Practice of Physical Fitness, 1983, 3, 21-23.

42. Leedyard, A. Running to Peak Performance, M., 1968.

43. Lipovetskey, B.M. Medical Affairs, 1984, 6, 25-28.

44. Lusov, V.A., Gorbachenko, A.A. Cardiology, 1982, 5, 102-107.

45. Makeyeva, N.N. , Temkin, I.B. Health andRunning, M., 1976.

46. Markarian, S.S. Archives of Therapy, 1984, 1, 87-91

47. Matov, V.V. Medical Control, M., 1983.

48. Menschikov, V.V. Cardiology, 1980, 11, 23-28.

49. Melnik, L.U. Physical Fitness, Work, Health, and Present-Day Longevity, 1981, p. 46.

50. Metelitza, V.I. , Mazur, N.A. Epidemiology and Prevention of Ischemic Heart Disease, M., 1976.

51. Mischenko, V.P. Issues in Medical Chemistry, 1985, 1, 99-102.

52. Motilyanskaya, R.E. Issues in Health Spa Science, Physiotherapy and Therapeutic Physical Exercise,1982, 5, 8-11.

53. Myakinchenko, E.V. Theory and Practice of Physical Fitness, 1984, 9, 21.

54. Nikolayeva, L.F. ,Markarian, S.S. Cardiology, 1983, 9, 69-72.

55. Pirogova, L.A. Issues in Health Spa Science, Physiotherapy and Therapeutic Physical Exercise, 1983, 6, 35-37.

56. Prikladovitzky, S. Archives of Medical Science, 1930, 11, p. 17.

57. Revutzkey, E.A. Medical Affairs, 1984, 1, 75-79.

58. Rudnitzkey, S. (Contributor in book): Modern Achievements in Rehabilitation of Myocardial Infarction Patients, M., 1983, 34-48.

59. Saprokhey, M.I. Physiological Journal of the U.S.S.R., 1935, 19, 4, p. 854.

60. Smolyakova, G.N. Physical Fitness, Work, Health, and Present-Day Longevity, 1981, 119-120.

61. Joint Research U.S.S.R.—U.S.A. on the Prevalance of Dislipidemia in the Populations of the Soviet Union and United States. Therapeutic Archives, 1977, 4, 26-37.

62. Shkhvatzabaya, I.K., Anderson G. (eds.). Modern Achievements in Rehabilitation of Myocardial Infarction Patients, M., 1983, 34-48.

63. Suslov, F.P. Legkaya Athletica, 1984, 3, 11-12.

64. Farfel, V.S. Theory and Practice of Physical Fitness, 1984, 9, 21.

65. Furkalo, N.K. Cardiology, 1984, 2, 55-56

66. Kharre, D. Evaluation of Training, M., 1971.

67. Tzikuley, A.E. Cardiology, 1984, 2, 113-114.

68. Chazov, E.I. Therapeutic Archives, 1976, 6, 3-11.

69. Chazov, E.I. Cardiology, 1973, 2, 3-24.

70. Chazov, E.I. Cardiology, 1972, 8, 15-19.

71. Chebotarev, D.F. Physiological Journal, 1984, 1, 53-58.

72. Chernigovskaya, S.V. Cardiology, 1984, 2, 79-82.

73. Chudnovskey, N.I., Gorbachenko, A.A. Cardiology, 1984, 2, 36-38.

74. Shalupnya, A.S. Issues in Sports Medicine, L., 1974, p.139.

75. Sharfnadel, M.G., Aronov, D.M. Cardiology, 1980, 6, 35-37.

76. Schtrutzenberger, E. Sports and Modern Society. Worldwide Scientific Congress, M., 1978, 120-140.

77. Shubik, V.M., Levin, M.J. Immunity and Health in Athletes, M., 1984.

78. Shkhvatzabaya, I.K., Aronov, D.M. Rehabilitation of Patients with Ischemic Heart Disease, M.,1978.

79. Yakovlev, N.N. The Biochemistry of Sports, M., 1974.

NON-RUSSIAN-LANGUAGE CITATIONS

80. Aaken, D.E. In: Long Distances, Tafnews Press, 1980, 57-61.

81. Adams, W., et al. Am J. Cardiology, 1974, N 6, 765-776.

82. Adams, W. et al. J. Appl. Physiology, 1975, 39: 1030-1037.

83. Aigner, A. Wien. Med. Wsch. , 1984, 135, 1, 5-9.

84. Allman, F.L. J. Occup. Med. , 1971, 13: 573-576.

85. Amery, R. Annals of the New York Academy of Science, 1977, 301: 50-54.

86. Amsterdam, E. Am. T. Cardiology, 1974, N6, 734-744.

87. Amsterdam E. Advances in Heart Disease, 1980, 345-362.

88. Andersen U., Shephard, R., Denolin, H., et. al. Fundamentals of Exercise Testing, WHO, Geneva, 1971, 135.

89. Andersen, L., Masironi, R., et al. Habitual Physical Activity and Health, Copenhagen, 1978 (Swedish language).

90. Apel, V.S., Tahn, U. Sports in the Aged from an Orthopedic Perspective, 1983, 38, 6, 427-433 (German language).

91. Astrand, P.O., Rodahl, U. Textbook of Work Physiology, New York, McGraw-Hill, 1970.

92. Bahmann, U., Mitarb, N. German Medical Weekly, 1970, 95: 741-748.

93. Ballantyne, D., Baller, D. Primary Cardiology, 1982, 8 6, 39-43.

94. Schenu et al. Z. Kardiol., 1979, 68: 656-662 (German language).

95. Barletta, G.A., et al. Europ. Heart T., 1983, 4, 11, 761-772.

96. Barnard, R.T., McAlpin, R.N., Cattus, A.A. Circulation, 1973, 48: 936-942.

97. Barr, D.P., et al. Am. T. Med., 1951, 11: 480-486.

98. Basse, E.I., et al. Eur. T. Appl. Physiol and Occup. Physiol. 1983, 52, 1, 120-125.

99. Bassler, T.I. Ann. N 4 Acad. Sci., 1977, 301: 579-592.

100. Baum, R.V. Sportsphysician and Sportsmedicine, 1971, 22: 20-28.

101. Berthezene, V. Rev. fr. endocrinol. clin. nutr et. metabol., 1983, 24, N 4-5, 355-358.

102. Blacklock, N.S. Am. J. Sports Med., 1979, 7: 239-241.

103. Blumenfeld, A. Heart Attack: Are You a Candidate?
New York, 1964.

104. Bonnano, J.A., Lies, J.E. Am. J. Cardiol., 1974, 33: 760-766.

105. Bonnet, P., Morand, P. Ann. Cardiology. Angiol., 1983, 32, 3, 71-176.

106. Bowerman, W., Harris, N. Jogging, Grossett & Dunlop, New York, 1967.

107. Boyden N., et al. Fertil. and Steril., 1983, 39, 56, 629.

108. Brousted, Y.P., et al. Ann. Cardiol Angiol., 1972, 21, 2, 111-127.

109. Brown, S., Graham, J. Target 26, Macmillan Publishing Co., 1979.

110. Bruce R.A., et al. Cardiology, 1977, 62: 83-84.

111. Buda A.I., Leven D., et al. Am. Heart J., 1978, 95: 457-462.

112. Cantwell, J.D. Phys. Ther., 1976, 56: 1026.

113. Cassel, J., Heyden, S., et al. Arch. Intern. Med., 1971, 128: 928-936.

114. Gastelli V., et al. Circulation, 1977, 55: 767-722.

115. Choquette, G., Fergussan, R. Canad. Med. Ass. J., 1973, 108: 699-705.

116. Clausen, J.P. Circulation, 1970, N 4, 611-624.

117. Clausen, J.P., et al. Circulation, 1976, 53: 436.

118. Coben, M.V., et al. J. Appl. Physiol. Respir. Environ. Exercise Physiol., 1982, 5, 320-326.

119. Cohen, M.W., et al. J. Appl. Physiol. Respir. Environ. Exercise Physiol., 1982, 5, 320-326.

120. Cooper, K.H. The New Aerobics, M. Evans and Co., New York, 1970.

121. Cooper, K.H., Pollock, M.L., et al. J. Am. Med. Assn., 1976, 236: 166.

122. Cooper, K.H. Running Without Fear. M. Evans and Co., New York, 1985.

123. Cornfield, J. Fed. Proc., 1962, 21, 2, 58-61.

124. Costill, D.L. J. Appl. Physiology, 1970, 28, 3, 251-266.

125. Costill, D.L. Arch. Environ. Health, 1970, 21, 520-523.

126. Costill, D.L. Fitness and Exercise, Chicago, Athletic Institute, 1972, 123-138.

127. Costill, D.L., et al. Med. Sci. Sports, 1974, 6: 95-100.

128. Costill, D.L. JAMA., 1972, 221: 1024-1029.

129. Costill, D.L. In: Long Distances, Tafnews Press, 1980, 129-132.

130. Costill, D.L. Med. and Science in Sport, 1969, 1: 81-86.

131. Council on Scientific Affairs. JAMA, 1981, 245: 1463-1466.

132. Cowan, G.O. Amer. J. Cardiol., 1983, 52, 4, 1313-1316.

133. Cullinane, E., et al. Metabolism, 1982, 31, 8, 844-847.

134. Dabrowska, G. Pol. Lyg. Lek., 1984, 39, 1, 1-15 (Polish).

135. Das Langret, E. & G. bei Herzgesunden. German Medical Weekly, 1983, 108, 14, 523-526.

136. Debusk, R.E., et al. Am. J. Cardiol., 1979, 44: 1223-1229.

137. DeMaria, A.V., Amsterdam, E.A., et al. Ann. Intern. Med., 1975, 84, 656-660.

138. Deuser, E. From Freetime to Performance Sport, Duesseldorf, 1977.

139. Dill D.B., et al. J. Gerontol., 1982, 37, 5, 565-571.

140. Ditchy, R.V., Watkins, J. Am. Heart J., 1981, 101: 701-707.

141. Ditchy, R.V., Watkins, J., et al. Am. Heart J., 1982, 106: 202-209.

142. Dlin R.A., et al. Am. Heart J., 1983, 106, 2, 316-320.

143. Doba N., et al. Jap. Circulat. J., 1983, 47, 6, 735-743.

144. Dorosiak, T., Nelson, T. J. Sports Med. and Phys. Fitness, 1983, 23, 3, 322-326.

145. Dressendorfer, R., Gahagen, H. The Physician and Sportsmed., 1979, 7: 119-128.

146. Dressendorfer, R., et al. In: Advances in Heart Disease (ed. D. T. Mason), Vol. 3, p. 381, New York, 1980.

147. Duran, M., et al. Physiology and Behavior, 1982, 29, 3, 449-454.

148. Durnin, J., Passmore, R. Energy, Work, and Leisure. London, Henemann, 1976.

149. Ebernhard A., Jasser, S. Przegl. Epid., 1967, 21, 4, 449-505.

150. Eckstein, R. W. Circ. Res., 1957, 5: 230.

151. Ehnholm C., et al. N. Engl. J. Med., 1982, 307, 14, 850-855.

152. Ehsani, A.A. Am. J. Cardiol., 1978, 42: 52-56.

153. Enger, S.C., et al. Scand. J. Clin. Lab. Invest., 1977, 27: 251.

154. Epstein, F.H. Circulation, 1973, 48, 1, 184-194.

155. Ferguson, R.T., et al. Circulation, 1978, 58: 41-47.

156. Fletcher, G., Cantwell, J.D. Exercise and Coronary Heart Disease, Springfield, J.L. Thomas, 1974.

157. Fnoelkher, V., et al. Cardiology, 1980, 65: 153-156.

158. Foster, C., et al. J. Appl. Physiol., 1982, 53, 2, 380-383.

159. Frank, C.W., et al. Circulation, 1966, 34: 1002.

160. Franke, K. Medicine and Sports, 1979, 19:1-6 (German).

161. Franklin, B.A. Arch. Phys. Med., 1978, 59: 276-280.

162. Franks, B.D., et al. J. Cardiac Rehabilit., 1983, 3, 4, 282-287.

163. Franz, L.W. Ergonometry in High-Jumpers, Berlin, 1982.

164. Frick, M.H. Mel. Cardiovasc., 1969, N1-2, 331-339.

165. Frick, M.H., et al. In: Coronary Heart Disease and Physical Fitness, Copenhagen, 1977, 43-47 (Danish).

166. Froelicher, V.E., Oberman, A. Prog. Cardiovasc Dis., 1972, 15(1): 41-65 (Danish).

167. Gibbons, L.W., Blair, S.N., Cooper, K.H. Circulation, 1983, 67, 5, 977-983.

168. Gollnick, P.D. Ann. N 4, Acad. Sci., 1977, 301: 64-71.

169. Gordon, T., Castelli, W., et al. Am. J. Med., 1977, 62: 707-721.

170. Gottheiner, V. Am. J. Cardiol., 1968, 22, 3, 426-435.

171. Graham, G.E. Med. J. of Australia, 1982, N 1(9), 389-390.

172. Haber, P., et al. Viennese Clinical Science, 1979, 91, 20, 693-696 (Austrian).

173. Hakuila, J. Med. Cardiovasc., 1969, N 1-2, 153-159 (Br.).

174. Hanson, J. Circulation Res. (Suppl. 1), 1970/1, 27, 49-54

175. Hartley, L.H., Mason, J.W., et al. J. Appl. Physiol., 1972, 33: 602-606.

176. Haskell, W.L. Circulation, 1978, 57: 920-924.

177. Haskell, W.L. In: Physical Conditioning and Cardiovascular Rehabilitation (eds.: S. Cohen, M.B. Moch), New York,1981.

178. Hebbelincu M., Casier, H. Angew. Physiol., 1966, 22: 185.

179. Hecuers, H., Platt, D. Med. Welt, 1982, 33, 15, 542-551.

180. Neinkinen, E., et al. Prot. Int. Symp. Exercise Biochem., 1973, 53: 119-123.

181. Hellerstein, H.B. Bull. N.Y. Acad. Med., 1968, N 8, 1028-47.

182. Hellerstein, H.B. Arch. Intern. Med., 1970, N 6, 987-999.

183. Hellerstein, H.B. Ann. N.Y. Acad. Sci., 1977, 301: 484-494.

184. Hermansen, L. Amer. J. Physiol., 1977, 233, 5, 422-424.

185. Heyden, S. German Health Science, 1982, 37, 31, 1353-60.

186. Hickson, R.C., et al. J. Appl. Physiol: Respir. Envion. and Exercise Physiol., 1982, 53, 1, 225-229.

187. Hollman, W. Hoechst und Danerlei-Stugstahigkeit des Sportles. Barth., Munich, 1963 (German).

188. Hollman, W. 12th Intern. Congr. Gerontol., Hamburg (West Germany), 1981, Abstr. Vol. 2, S.I.S.A., 198.

189. Holmberg S. Coronary Circulation at Rest, During Exercise and During Parcinginducted Tachycardia, G—teborg, 1971, p. 1-39 (Danish).

190. Howald, H. Swiss Medical Weekly, 1984, 114, 3, 110-112.

191. Humphreys, J., Holman, R. Focus of the Marathon, London, 1984.

192. Hyer, W.J., et al. Gerontology, 1984, 39, 1, 44-48.

193. Ismail, A.H., Naggot, A. J. Hum. Ergol., 1981, 10, 1, 83-91.

194. Israel, S. East German-Sports, 1982, N 5, 22-24.

195. Israel, S., et al. Medicine and Sports, 1982, 22: 322-359 (German).

196. Jacuson, D.W. Phys. Sportmed., 1978, 6(10), 41-61.

197. Joul, E. Med. Sport (Roma), 1973, 26, 2, 33.

198. Jones, R.J. JAMA, 1983, 247, 18, 2535-2537.

199. Jorgensen, C.R., et al. Circulation, 1974, 50: 1179.

200. Jung, H. J. Sport Med. and Phys. Fitness, 1982, 22, 1, 23-31.

201. Kagan, A.R., et al. Atherosclerosis of the Aorta and Coronary Arteries in Five Towns, Geneva, WHO, 1977.

202. Kahn, H.A. Am. J. Public Health, 1963, 53: 1085.

203. Kaiser, G. Medicine and Sport, 1977, 17: 79-88. (German).

204. Kannel, N., et al. In: Coronary Heart Disease and Physical Fitness, Copenhagen, 1971, 256-260.

205. Kaplan, N.H. Ann. Intern. Med., 1983, 98, 5, p. 11, 705-709.

206. Kattus, A.A., McAlpin, R.N.. Circulation, 1965, N 4, Suppl. 2, p. 122.

207. Kaufman, J.M., Anslow, R. JAMA, 1966, 196: 151-155.

208. Kaufmann, D.M. Track Technique U.S.A., 1977, N 70.

209. Kavanag, N.T., Shephard, R.T. JAMA, 1974, 229:1602-1605.

210. Kavanag, N.T., et al. Am. J. Physiol., 1979, 44: 1230-1240.

211. Kavanagh, T. The Healthy Heart Program, Toronto, Van Nostrand Reinhold, 1980.

212. Karanagh, T. Paper presented at 2nd World Congress on Cardiac Rehabilitaton, Jerusalem, 1981.

213. Kellerman, T.J. In: Exercise and Heart Disease, New York, 1978, p. 183-208.

214. Kever, F.W., Berget, M. The Unisch., 1983, 40, 10, 875-882.

215. Keys, A. Coronary Heart Disease in Seven Countries, New York, 1970.

216. Kikeli, P., et al. Rehabilitation, 1979, 12:72-75.

217. Kirsh, K. Endurance Sports, 1975, 3: 30-34 (German).

218. Kitamura, K., Torgensen, C.R. J. Appl. Physiol., 1972, 35: 516-520.

219. Koerner, J.E. J. Appl. Physiol.: Respir. Environ. Exercise Physiol., 1982, 53: 375-380.

220. Koehler, H. Run Yourself Healthy, Berlin, 1981.

221. Koivisto, V. et al. Metabolism, 1982, 31: 192-201.

222. Koste, Markku, Sherman, D.E. Lancet, 1982, N 8293, 327-328.

223. Kramsch, D.M. New Engl. J. Med., 1981, 305: 1483-1489.

224. Kukkonen, K. Clinical Physiology, 1982, 2, 3, 351-256.

225. Kullev, L., et al. Medicine, 1967, 46:341-348.

226. Kunsui, H., et al. Wyehow fiz sport, 1982, 26, 7, 13-19.

227. Kuroda, M.D. J. Sport Med. and Physiol. Fitness, 1982, 22, 1, 1-16.

228. Lampton, R.M. Circulation, 1977, 55: 652-660.

229. Larsen, O.A., et al. Acta Pediat., 1963, 52: 530-536.

230. Larsen, O.A., Larsen, N.A. Lancet, 1966, 2: 1093-1096.

231. Lehtonen, A. Acta Med. Scand., 1978, 204: 111-118.

232. Lenzas, G. Heisport in der Orthopaedic VEB Verlag Volk und Gesundheit, Berlin, 1976.

233. Leon, A.S., Bloor, C.M. Adv. Cardiol., 1976, 18: 81-90.

234. Leveni, J. Phys. Sport. Med., 1979, 7(8), 40-49.

235. Litjefors, J. Acta Med. Scand., 1970, Suppl. 511.

236. Magaranin, A.J. J. Appl. Physiol., 1974, 36: 214-217.

237. Maucini, M., Rubba, P. Arter. Pollut: Intern. Viev Atheroscler. Proc. NATO Adv. Study Inst., New York, London, 1983, p. 277-288.

238. Manley, J.C. In: Heart Disease and Rehabilitation (ed. M.L. Pollocu), Boston, p. 168.

239. Margaria, R.J. Appl. Physiol., 1963, 18: 367-370.

240. Maron, M.B., Horvath, S.M. J. Appl. Physiol., 1976, 40:836-838.

241. Maron, M.B., Wagner, J.A. J. Appl. Physiol., 1977, 42: 909-914.

242. Maron, M.B., Horvath, S.V. Med. and Science in Sports, 1978, 10, 2, 137-150.

243. Maron, B.L. Circulation, 1980, 62: 218-229.

244. Marshall, R.N. New Zealand Medical Journal, 1978, 88: 228-90.

245 Master, A., Geller, A.J. Am. J. Cardiol., 1969, 29: 173-179.

246. Mazarello, T.A., Tordan, I. Circulation, 1954, 32, 4, 147 (Suppl. 2).

247. Mellerowicz, H. In: Rehabilitation Kardiologie, hrsg. von H. Mellerowicz, Basel, 1974 (Swiss-German lang.).

248. Miller, G.J., Miller, N.E. Lancet, 1975, 1: 16-19.

249. Miller, N.E. Biochim. Biophys: Acta, 1978, 529: 131-137.

250 Mondermar, P. Olimpic Rewu., 1981, n 165-166, p. 131-144.

251. Montoge, H.T., et al. Med. Sci. Sports, 1972, 4: 125-181.

252. Morris, T.N. Mod. Conc. Cardiovasc. Dis., 1961, 30: 633.

253. Morris, T.N., et al. Lancet, 1953, 2: 1053-1057.

254. Morris, N.N. Lancet, 1980, 11: 1207.

255. Morsher, E.Z. Unfallmed U. Berufseru., 1974, 66: 223-231.

256. Mulcahy, R., et al. Am. J. Public Hlth., 1970, 60: 1515-1521.

257. Myocardial infarction community registers. Copenhagen, WHO Regional Office for Europe, 1976.

258. Nanamura N. Atherosclerosis, 1983, 48, 2, 173-183.

259. Naliwajka, A. Atherosclerosis, 1979, 60: 114-121.

260. Naruhino, N., Tunko, A., Takeani, I. J. Hum. Ergol. 1982, 11, 2, 175-186.

261. Naughton, J., et al. Arch. Physiol. Med., 1968, N 3, 131-137.

262. Naughton, J. In: Heart Disease and Rehabilitation (ed. M.L. Polocu), Boston, 1979, p. 330.

263. Nelson, R.R. Circulation, 1973, 50: 1173-1180.

264. Neuman, G. Medizin und Sport, 1983, 23, 6, 169-175.

265. Newman, P.E. Am. Heart J., 1981, 102, 102: 441-440.

266. Hilsson, S. Scand. Soc. Med. Suppl., 1982, 29: 171-178.

267. Ninimaa V. Respiratory Physiology, 1983, 53, 1, 129-133.

268. Noakes, T.D., et al. New England J. Med., 1979, 301: 86-89.

269. Northote, R.T., Ballautyne, D. Brit. Med. J., 1983, 287, N6401, 1357-1359.

270. O'Herlihy, C.M. New England J. Med., Jan. 7, 1983, N 1, p. 51.

271. Oldridge, N.B. Med. Sci. Sports, 1979, 11: 373-375.

272. Paffenbarger, R., et al. N. Engl. J. Med., 1974, 229: 545-550.

273. Paffenbarger, R., et al. Am. J. Epidemiol., 1978, 108: 161-175.

274. Paffenbarger, R., Wing, A.L. Cardiac Rehabilitation, 1979, 10: 1-6.

275. Paffenbarger, R.J. Am. Med. Ass., 1984, 252, 4, 27-31.

276. Pantano, M.D., et al. Am. Heart J., 1982, N 10, 762-768.

277. Pansold, B. et al. Med. und Sport, 1982, 22, 4, 107-112.

278. Penny, C., et al. J. Sport Med., 1981, 21: 395-400.

279. Perrault, H., et al. Intern. J. Sport Med., 1982, 3, 3, 151-144.

280. Peterson, Z., Rentroem, R. Skador inom idrotten, Hocholm, 1977.

281. Pilcher, G.F., et al. Amer. Cardiology, 1983, 52, 2, 859-861.

282. Polloek, M.L. Phys. Sportmed., 1978, 6(6), 50-64.

283. Pritikin, N. Runner's World, 1984, p. 60-66.

284. Rafto, J.A., et al. British Heart J., 1980, 43: 262-269.

285. Reindell, H., Roskamm, H. Das Intervall Training, Munich, 1962.

286. Reinhold, D. Med. und Sport, 1982, 22: 64-65.

287. Report Intern Society. Circulation, 1970, 42, p. A55-A95.

288. Reuter, W., Hermann, W. Z. Alternsorsch., 1982, 37, 5, 315-328.

289. Riley, W.J., et al. Clin. Chim. Acta, 1975, 65: 83-89.

290. Robinson, B.F. Circulation, 1967, N 6, 1073-1083.

291. Rose, G.A., Blackburn, H. Cardiovascular Survey Methods, WHO, Geneva, 1968, 188 p.

292. Rossi, A., et al. Cardiology, 1979, 64: 372-375.

293. Rossi, A., et al. Amer. J. Clin. Nutr., 1982, 36, 3, 478-484.

294. Rost R. Munch. Med. Wschr., 1983, 125, 45, 1025-1028.

295. Roth, D. Circulation, 1980, 62: 883-891.

296. Sanne, H. Acta Med. Scand., 1973, Suppl. 551.

297. Sanne, H. Preventive Effect of Physical Training after a Myocardial Infarction, Stockholm, 1972.

298. Sannerstedt, R. Advanc. Cardiol., 1978, 24:164-168.

299. Sauntamaerik, J. Scand. J. Rehabilitation. Med., 1978, 10:155-162.

300. Schoper, W. Circulation, 1982, 65: 905-912.

301. Schellbacker, H. Herz Kreizl., 1974, 6: 2092-2098

302. Schenk, K.E. Z. Allgemeinned., 1980, 56: 452-459

303. Schephard, R., et al. Fundamentals of Exercise Testing, Geneva, 1971.

304. Scheuer, J. Inform. Cardiol., 1983, 7, 5, 413-417.

305. Schmith, G, Israel, S. Med. und Sport, 1983, 23: 158-160.

306. Schwalib, H. In: Rehabilitatiove Kardiologie (hrsg. Von. H. Mellerowiez), Basel, 1974.

307. Schwalib, H. Med. Klin., 1978, 73:1203-1209.

308. Selvester, R. Ann. J. N 4 Acad. Sci., 1977, 301: 495-501.

309. Shapiro, S., et al. J. Chron. Dis., 1965, 18: 527-531.

310. Shaw, L.W., et al. Am. J. Cardiol., 1981, 48: 39-50.

311. Shephard, R.T. Intern. Z. Angew. Physiol., 1968, 26: 272-278 (German language).

312. Shephard, M.D., et al. J. Cardiac Rehabil., 1983, 3, 5, 321-329.

313. Shephard, R. J. Cardiac Rehabil., 1983, 3, 4, 294-298.

314. Sidney, K.H. Med. Sci. Sports, 1977, 8: 246-252.

315. Simborg, D.W. J. Chron. Dis., 1970, 22: 515-552.

316. Squiers, R.W., et al. J. Cardiac Rehabil., 1983, N 8, 570-574.

317. Stamler, J. Med. Clin. N. Am., 1973, 54: 5-46.

318. Stone, H.L. J. Appl. Physiol., 1980, 49: 759-796.

318A. Sugishita, Y., et al. Jap. Circulat. J., 1983, 47, 5, 562-572.

319. Sunmers, J.T., et al. Percept. and Mot. Skills, 1982, 54, 3, Part I, 963-969.

320. Tharp, G.D., Wagner, C.T. Europ. J. Appl. Physiol., 1982, 48: 97-102.

321. Thompson, P.D., et al. JAMA, 1982, 247: 25-35.

322. Thompson, P.D., et al. JAMA, 1979, 242: 1265-1267.

323. Tubau, J., et al. Am. Heart J., 1982, 104: 238-242.

324. Tuckman, B.W., Gondola, J.C. Percept. and Motor Skills, 1983, 51, 1, 333-334.
325. Turblin, J. Nouv. Rev. Med. Toulouse, 1984, 2, 4, 200-201.
326. Ueshima, H., et al. Circulation., 1982, 66, 3, 519-526.
327. Vihert, A. In: Myocardial Infarction., Basel, 1967.
328. Virmani, R., et al. Am. J. Med., 1982, 72: 874-882.
329. Vuori, I. Med. Sci. Sports Exercise, 1982, 14: 114.
330. Wahren, J. In: Ann. J. N 4 Acad. Sci., 1977, 301: 45-55.
331. Waller, B.E., Roberts, W.C. Am. J. Cardiol., 1980, 45: 1292-1230.
332. Wasserman, K., et al. J. Appl. Physiol., 1973, 35, 2, 236-243.
333. Wegerts, O. J. Appl. Physiol., 1970, 29: 208-218.
334. Weiner, D.A., et al. Am. Heart J., 1983, 105, 5, 749-755.
335. Weldener, T., Melerowicz, H. Internist, 1970, 11: 287.
336. Wendt, Th., Scherer, D. Dtsch. Med. Wochenschr., 1984, 109, 4, 123-127 (German language).
337. WHO Chron., 1969, 2, 8, 355-367.
338. Williams, R.S., et al. New England J. Med., 1980, 302: 987-988.
339. Wilmore, J.H., et al. Med. and Science Sports, 1970, 2: 7-14.
340. Winterfeld, H.J., et al. Z. Intern. Med., 1983, 38, 18, 494-497 (German language).
341. Witelus, J. Wiad Lek, 1983, 36, 14, 1147-1154.
342. Wo, R., Borrow, J., et al. Amer. J. Clin. Nutr., 1982, 36, 3, 480-487a.
343. Wood, P.D., et al. In: Ann. N.Y. Acad. Sci., 1977, 301, 749-763.
344. Wyatt, H.L., Mitchell, J. J. Appl. Physiol., 1978, 45: 611-625.
345. Yano, K., et al. J. Chron. Dis., 1983, 36, 8, 569-580.
346. Yoshida, T., et al. Env. J. Appl. Physiol. and Occup. Physiol., 1982, 49, 2, 223-230.
347. Zinkraf, S., et al. J. Sport Med. and Physiol. Fitness, 1983, 23, 2, 210-212.
348. Zohman, L.R., Tobis, T.S. Cardiac Rehabilitation, Grune Stratton, Inc., New York, 1970.

MAN & RUNNING

Vladimir M. Volkov

[illegible]

Evgeny G. Milner

[illegible] Smolensk State Institute of Physical Culture [illegible] in addition to lecturing [illegible]

Daniel C. Drew

is a family physician with a keen interest in the health and fitness aspects of running. He [illegible] private practice in [illegible] Indiana [illegible] the translation of this Russian bestseller on running and health. He is now located in Danville [illegible]

[illegible] Sport and Physical Education

[illegible]

BEST COPY AVAILABLE